Radiation Data and Reports

VOLUME 15, NUMBER 11

NOVEMBER 1974

(Pages 697–756)

RDDRA4 15(11) 697–756 (1974)

U.S. ENVIRONMENTAL PROTECTION AGENCY

Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	j	j'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
A	ampere(s)	
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps-2.22×10^{12} dpm
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	3.527×10^{-2} ounces= 2.205×10^{-3} pounds
Hz	hertz	cycle per second
kVp	kilovolt peak	
m	meter(s)	39.4 inches=3.28 feet
m^3	cubic meter(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
mi	mile(s)	
ml	milliliter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g
r/min	revolutions per minute	
s	second	
yr	year	

RADIATION DATA AND REPORTS

Volume 15, Number 11, November 1974

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

CONTENTS

CONTENTS—continued

RADIATION DATA AND REPORTS

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U.S. ENVIRONMENTAL PROTECTION AGENCY

Russell E. Train, Administrator

SECTION I. MILK AND FOOD

Milk Surveillance, June 1974

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations: 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological be-

Figure 1. Milk sampling networks in the Western Hemisphere

havior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 $\pm$ 0.08 g/liter for calcium and 1.51 $\pm$ 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Research and Development Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reports in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131: (96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137: (53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89: (29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90: (32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

a quarterly basis for certain nuclides. The frequency of collection and analyses varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in connection of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the sta-

Table 2. Concentrations of radionuclides in milk for June 1974 and 12-month period, July 1973 through June 1974

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	3	0	2
Alaska	Palmer[c]	P	NA	3	13	3
Ariz:	Phoenix[c]	P	NA	0	0	1
Ark:	Little Rock[c]	P	NA	12	11	3
Calif:	Los Angeles[c]	P	NA	0	0	0
	Sacramento[c]	P	NA	0	0	2
	San Francisco[c]	P	NA	0	0	0
	Del Norte	P	NA		NA	
	Fresno	P	NA		NA	
	Humboldt	P	NA		NA	
	Los Angeles	P	NA		NA	
	Mendocino	P	NA		NA	
	Sacramento	P	NA		NA	
	San Diego	P	NA		NA	
	Santa Clara	P	NA		NA	
	Shasta	P	NA		NA	
	Sonoma	P	NA		NA	
Colo:	Denver[c]	P	NA	0	0	0
	East	R	NS	NS	NS	NS
	Northeast	R	NS	NA	NS	4
	Northwest	R	NS	NA	NS	0
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NA	NA	0	0
	West	R	NS	NA	NS	0
Conn:	Hartford[c]	P	NA	4	16	1
	Central	P	NA		NA	
Del:	Wilmington[c]	P	NA	8	0	1
D.C:	Washington[c]	P	NA	4	0	1
Fla:	Tampa[c]	P	NA	4	20	25
	Central	R	3	5	15	26
	North	R	NA	6	19	13
	Northeast	R	4	6	18	25
	Southeast	R	5	5	34	41
	Tampa Bay area	P	4	4	17	24
	West	R	7	8	15	11
Ga:	Atlanta[c]	P	NA	4	14	3
Hawaii:	Honolulu[c]	P	NA	0	0	0
Idaho:	Idaho Falls[c]	P	NA	3	0	0
Ill:	Chicago[c]	P	NA	5	0	0
Ind:	Indianapolis[c]	P	NA	5	0	3
	Central	P	NA		NA	
	Northeast	P	NA		NA	
	Northwest	P	NA		NA	
	Southeast	P	NA		NA	
	Southwest	P	NA		NA	
Iowa:	Des Moines[c]	P	NA	4	0	0
	Des Moines	P	5	5	0	0
	Iowa City	P	6	5	0	0
	LeMars	P	NS	4	NS	0
	Little Cedar	P	6	6	0	0
Kans:	Wichita[c]	P	NA	6	11	2
	Coffeyville	P	9	6	NA	7
	Dodge City	P	4	4	NA	7
	Falls City, Nebr	R	NS	5	NA	8
	Hays	P	9	6	NA	5
	Kansas City	P	10	5	NA	5
	Topeka	P	10	6	NA	6
Ky:	Louisville[c]	P	NA	5	12	3
La:	New Orleans[c]	P	NA	8	13	6
Maine:	Portland[c]	P	NA	8	14	11
Md:	Baltimore[c]	P	NA	8	13	3
Mass:	Boston[c]	P	NA	8	13	5
Mich:	Detroit[c]	P	NA	6	0	3
	Grand Rapids[c]	P	NA	7	0	p
	Bay City	P	7	10	0	2
	Charlevoix	P	6	9	0	2
	Detroit	P	4	9	0	0
	Grand Rapids	P	11	13	0	5
	Lansing	P	10	11	0	3
	Marquette	P	9	12	15	6
	Monroe	P	30	14	0	2
	South Haven	P	11	14	0	2
Minn:	Minneapolis[c]	P	NA	7	0	0
	Bemidji	P	5	6	11	0
	Duluth	P	11	16	11	14
	Fergus Falls	P	7	7	0	0
	Little Falls	P	29	13	81	29
	Mankato	P	5	5	0	0
	Marshall	P	NS	3	NS	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for June 1974 and 12-month period, July 1973 through June 1974—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
Minn:	Minneapolis	P	11	9	0	0
	Rochester	P	6	5	0	0
Miss:	Jackson*	P	NA	8	0	4
Mo:	Kansas City*	P	NA	4	0	0
	St. Louis*	P	NA	8	14	2
Mont:	Helena*	P	NA	0	0	0
Nebr:	Omaha*	P	NA	0	11	1
Nev:	Las Vegas*	P	NA	8	0	0
N.H:	Manchester*	P	NA	9	13	5
N.J:	Trenton*	P	NA	4	12	1
N. Mex:	Albuquerque*	P	NA	0	0	0
N.Y:	Buffalo*	P	NA	6	0	0
	New York City*	P	NA	4	12	2
	Syracuse*	P	NA	6	14	3
	Albany	P	6 (3)	4	0	0
	Buffalo	P	3	5	0	0
	Massena	P	5	7	15	10
	New York City	P	9	6	0	0
	Syracuse	P	13	5	10	0
N.C:	Charlotte*	P	NA	9	12	5
	Asheville	P	7		0	
	Charlotte	P	8		14	
	Lexington	P	10		0	
	New Bern	P	7		15	
	Raleigh	P	7		13	
	Wilkesboro	P	10		22	
N. Dak:	Minot*	P	NA	6	11	1
Ohio:	Cincinnati*	P	NS	6	NS	3
	Cleveland*	P	NA	7	0	1
Okla:	Oklahoma City*	P	NA	2	14	1
Oreg:	Portland*	P	NA	0	0	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia*	P	NA	5	0	1
	Pittsburgh*	P	NA	10	11	2
	Dauphin	P	NA		NA	
	Erie	P	NA		NA	
	Philadelphia	P	NA		MA	
	Pittsburgh	P	NA		NA	
R.I:	Providence*	P	NA	4	14	6
S.C:	Charleston*	P	NA	5	17	9
	Anderson–01	R	7	7	0	2
	Anderson–02	R	6	6	0	3
	Chapin	R	NS	7	NS	8
	Clemson	R	6	8	0	8
	Columbia	R	NS	7	NS	11
	Fairfield	R	NS	6	NS	11
	Hartsville–02	R	6	6	11	9
	Hartsville–03	R	NS	13	NS	13
	Lee County	R	NS	7	NS	9
	Oconee County	R	7	7	0	5
	Pickens	R	7	7	0	9
	Williston	R	NS	7	NS	15
	Winnsboro	R	NS	6	NS	15
	York–01	R	NS	7	NS	5
	York–02	R	NS	5	NS	0
S. Dak:	Rapid City*	P	NA	8	0	1
Tenn:	Chattanooga*	P	NA	6	12	3
	Knoxville*	P	NA	0	13	3
	Memphis*	P	NA	6	0	2
	Chattanooga	P	NA	8	11	3
	Clinton	R	NA	9	14	3
	Fayetteville	R	NA	9	14	4
	Kingston	R	NA	9	18	3
	Knoxville	P	NA	7	12	4
	Lawrenceburg	R	NA	5	0	0
	Nashville	P	NS	6	NS	0
	Pulaski	R	NA	3	0	0
	Sequoyah	R	NS	9	NS	0
Tex:	Austin*	P	NA	0	0	0
	Dallas*	P	NA	3	11	1
Utah:	Salt Lake City*	P	NA	0	0	0
Vt:	Burlington*	P	NA	5	12	3
Va:	Norfolk*	P	NA	6	11	1
Wash:	Seattle*	P	NA	0	17	3
	Spokane*	P	NA	4	0	0
	Benton County	R	NS	0	NS	0
	Franklin County	R	0	1	0	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for June 1974 and 12-month period, July 1973 through June 1974—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
Wash:	Longview	R	7	5	0	7
	Sandpoint, Idaho	R	7	5	0	1
	Skagit County	R	8	5	11	2
W. Va:	Charleston[c]	P	NA	8	12	1
Wisc:	Milwaukee[c]	P	NA	3	0	1
Wyo:	Laramie[c]	P	NA	0	0	1
CANADA:						
Alberta:	Calgary	P	NA		6	5
	Edmonton	P	NA		14	8
British Columbia:	Vancouver	P	NA		19	12
Manitoba:	Winnipeg	P	NA		8	8
New Brunswick:	Moncton	P	NA		10	8
Newfoundland:	St. John's	P	NA		27	13
Nova Scotia:	Halifax	P	NA		16	8
Ontario:	Ottawa	P	NA		9	6
	Sault Ste. Marie	P	NA		19	13
	Thunder Bay	P	NA		13	10
	Toronto	P	NA		6	5
	Windsor	P	NA		7	5
Quebec:	Montreal	P	NA		9	4
	Quebec	P	NA		16	12
Saskatchewan:	Regina	P	NA		7	4
	Saskatoon	P	NA		4	5
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal[c]	P	NA	0	0	0
Chile:	Santiago	P	0	0	18	2
Colombia:	Bogota	P	3	2	0	0
Ecuador:	Guayaquil	P	0	1	22	2
Jamaica:	Montego Bay	P	NS		NS	
Puerto Rico:	San Juan[c]	P	NA	3	12	2
Venezuela:	Caracus	P	0	0	0	0
PMN network average[d]			NA	5	6	2

[a] P, pasteurized milk,
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

tions which are reported routinely in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for

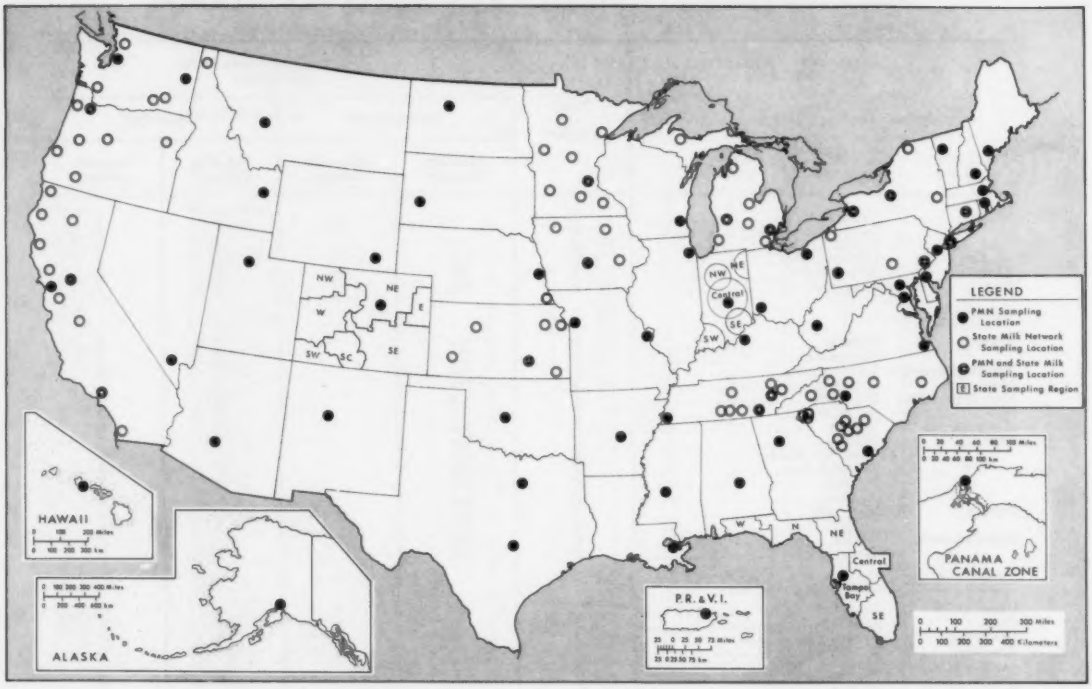

Figure 2. State and PMN milk sampling stations in the United States

strontium-90 and cesium-137 for June 1974 and the 12-month period, July 1973 to June 1974. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for June 1974 were below the respective practical reporting levels.

Strontium-90 monthly averages ranged from 0 to 30 pCi/liter in the United States for June 1974 and the highest 12-month average was 18 pCi/liter (Little Falls, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 81 pCi/liter in the United States for June 1974, and the highest 12-month average was 41 pCi/liter (Southeast Florida) representing 1.1 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Radiologic Health Section
Environmental Control Component
California Department of Health

Radiation Protection Bureau
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Laboratory Division
Connecticut Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

State Hygienic Laboratory
Medical Laboratories Building
Iowa City, Iowa

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Radiation Protection Branch
Division of Facility Services
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Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina Department of Health and Environmental Control

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-90 measurements in milk, June 1972, Technical Experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet	July 1971–1972	February 1974
Carbon-14 in Total Diet and Milk	1972–1973	November 1973
Strontium-90 in Tri-City Diets	1972	December 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analyses programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
ERAMS Surface Water and Drinking Water Components	January–March 1974	August 1974
Florida	1970	April 1974
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1972	August 1974
Minnesota	July 1971–June 1972	March 1974
New York	1972	June 1974
North Carolina	1971	July 1974
Radiostrontium in Tap Water, HASL	1972	December 1973
Washington	July 1971–June 1972	October 1974

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas	1972	August 1974
Krypton-85 in air	July 1970–1972	March 1974

1. ERAMS Gross Radioactivity and Deposition Component, June 1974

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973, was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Gross Radioactivity and Deposition Component is a restructuring of the previous Radiation Alert Network (RAN). Sampling stations were relocated to more closely monitor the potential sources of environmental radioactivity and to provide the means for obtaining the maximum population coverage. The component consists of 74 sampling stations, 54 of which are on standby status and can be activated when the need arises. The remaining 20 stations collect air particulates continuously with the filters being changed one or two times per week. Most of the stations are operated by State or local health department personnel.

The station operators perform gross beta radioactivity "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples, which are collected concurrently at the 20 air sampling stations, are sent to the Eastern Environmental Radiation Facility for laboratory gross beta radioactivity analyses. All field estimate results are reported to the appropriate Environmental Protection Agency officials by mail or telephone depending on the levels found. A compilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109.

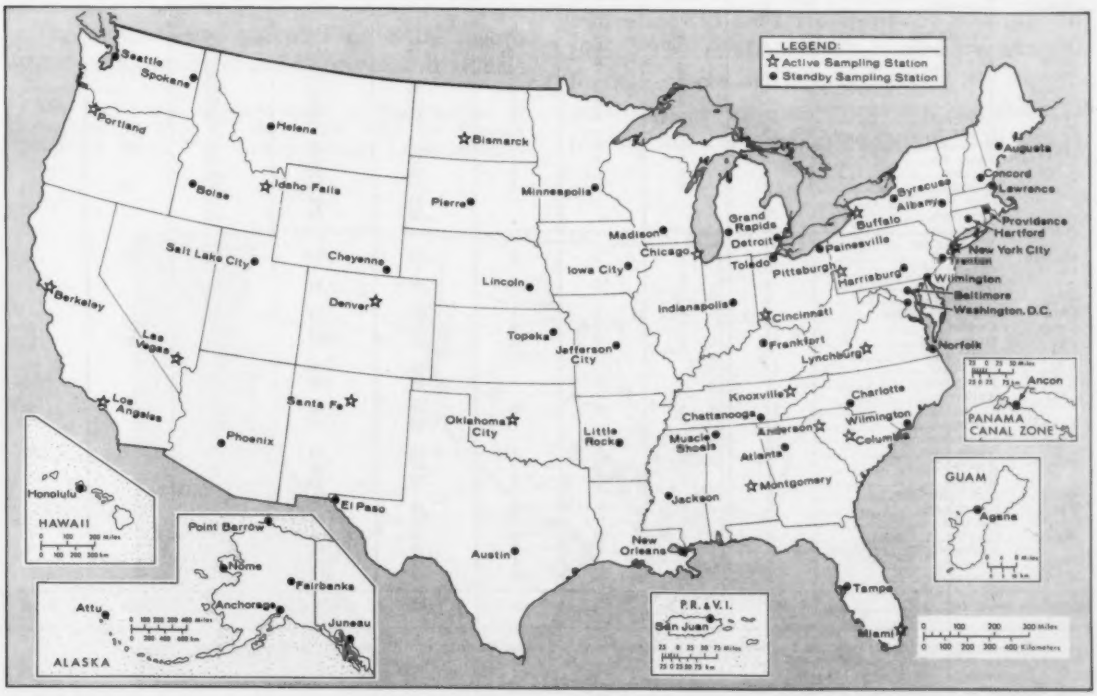

Figure 1. ERAMS Gross Radioactivity and Deposition Component sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1974

Station location		Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation	
			5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
			Maximum	Minimum	Average [a]	Maximum	Minimum	Average [a]	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	12	2	0	1	0.20	0.09	0.14	56	0.47
	Muscle Shoals	0								
Alaska:	Anchorage	6	0	0	0	.05	.01	.03		
	Attu Island	9	0	0	0	.02	<.01	<.01		
	Fairbanks	7				.08	.03	.06		
	Juneau	0								
	Nome	0								
	Point Barrow	0								
Ariz:	Phoenix	3	3	1	2	.30	.20	.26		
Ark:	Little Rock	7	2	0	1	.23	.07	.14		
Calif:	Berkeley	15	0	0	0	.38	.05	.11		
	Los Angeles	13	3	0	1	.68	.03	.18		
C.Z:	Ancon	5	0	0	0	.02	<.01	.02		
Colo:	Denver	10	4	1	2	.30	.14	.20	40	.32
Conn:	Hartford	8	2	0	1	.16	<.01	.09		
Del:	Wilmington	6	1	0	0	.16	.03	.11		
D.C:	Washington	8	1	0	0	.28	.07	.15		
Fla:	Jacksonville [b]	6	1	0	0	.20	.07	.12		
	Miami	7	0	0	0	.08	.02	.05	55	.76
Ga:	Atlanta	6				.25	.16	.21		
Guam:	Agana	0								
Hawaii:	Honolulu	8	0	0	0	.35	.05	.11		
Idaho:	Boise	8	2	1	1	.38	.15	.22		
	Idaho Falls	8				.36	.13	.23		
Ill:	Chicago	5	5	0	2	.23	.07	.13		
Ind:	Indianapolis	4	0	0	0	.23	.10	.16		
Iowa:	Iowa City	4	4	1	2	.18	.15	.17		
Kans:	Topeka	8	6	1	3	.27	.07	.14		
Ky:	Frankfort	7	1	0	1	.13	.08	.10		
La:	New Orleans	5	1	0	1	.24	.11	.17		
Maine:	Augusta	7	1	0	0	.15	.03	.09		
Md:	Baltimore	7	1	0	1	.18	.05	.10	10	<.01
Mass:	Lawrence	0								
Mich:	Grand Rapids	0								
	Lansing [c]	5	2	0	1	.16	.08	.12	28	.50
Minn:	Minneapolis	3	2	1	2	.24	.18	.21		
Miss:	Jackson	7	2	0	1	.20	.09	.14	5	.07
Mo:	Jefferson City	6	5	0	3	.21	.08	.14	17	.15
Mont:	Helena	7	3	1	2	.30	.15	.20		
Nebr:	Lincoln	7	5	3	4	.82	.12	.29		
Nev:	Las Vegas	12	2	0	1	.44	.12	.23		
N.H:	Concord	0								
N.J:	Trenton	6	1	0	1	.18	.02	.09	41	1.23
N. Mex:	Santa Fe	12	2	0	1	.23	.09	.14		
N.Y:	Albany	4	1	0	1	.18	.02	.09		
	Buffalo	8	1	0	1	.37	.09	.25	2	.05
	New York City	6				.33	.04	.16		
	Syracuse	10				.20	.04	.10		
N.C:	Charlotte	0								
	Wilmington	0								
N. Dak:	Bismarck	13	7	1	3	.31	.13	.22	24	.96
Ohio:	Cincinnati	0								
	Columbus [d]	9	1	0	1	.26	.06	.14		
	Painesville	0								
Okla:	Oklahoma City	6	2	1	1	.21	.07	.14		
Oreg:	Portland	12	0	0	0	.18	.04	.10	27	.49
Pa:	Harrisburg	15	2	0	1	.27	<.01	.13	22	1.0
	Pittsburgh	0								
P.R:	San Juan	11				.13	.04	.09		
R.I:	Providence	8	1	0	1	.20	.02	.12		
S.C:	Anderson	0								
	Columbia	11	2	0	1	.29	.08	.17	79	1.96
S. Dak:	Pierre	11				.32	.17	.24		
Tenn:	Chattanooga	0								
	Nashville [e]	7	2	0	1	1.55	.09	.35	8	.09
Tex:	Austin	7	7	2	5	.27	.06	.16		
	El Paso	7	3	0	2	.23	.04	.11		
Utah:	Salt Lake City	0								
Va:	Lynchburg	5	1	0	1	.13	.06	.10		
	Norfolk	7	0	0	0	.27	.03	.11		
Wash:	Seattle	4	0	0	0	.09	.04	.07		
	Spokane	7	3	1	1	.18	.11	.15		
Wisc:	Madison	6	2	0	1	.19	.03	.14		
Wyo:	Cheyenne	6	4	0	2	.26	.12	.19		
Network summary		444	7	0	1	1.55	<0.01	0.14	30	0.58

[a] The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.
[b] Station to be relocated to Tampa.
[c] Station to be relocated to Detroit.
[d] Station to be relocated to Toledo.
[e] Station to be relocated to Knoxville.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during June 1974. The standby stations were activated following the June 17, 1974 detonation of an atmospheric nuclear test by the Peoples Republic of China. Activity levels did not exceed those normally attributed to ambient variations.

2. Air Surveillance Network, June 1974

National Environmental Research Center—Las Vegas
Environmental Protection Agency

The Air Surveillance Network,[1] operated by the National Environmental Research Center —Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged after periods generally ranging from 48 to 72 hours. All standby stations except six stations near the NTS were activated on June 19 for the purpose of checking on the operability of the stations and collecting radioactive fallout from a nuclear detonation conducted by the Peoples Republic of China on June 16, 1974. All samples are mailed to the NERC-LV. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m³. For reporting purposes, concentrations less than 1.0 pCi/m³ are reported to one significant figure,

[1] This network is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

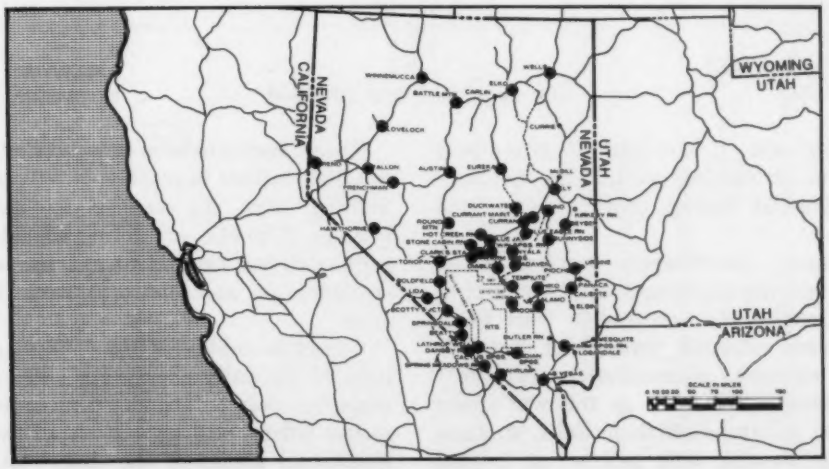

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

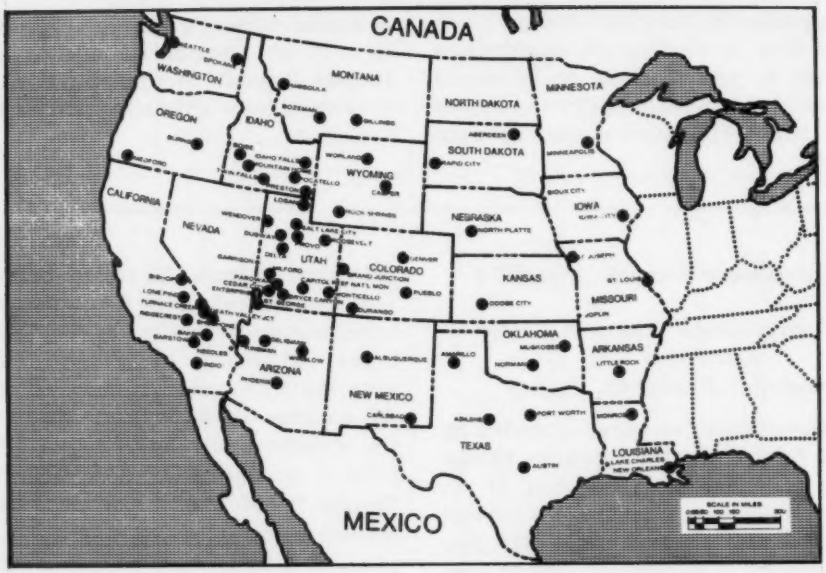

Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

and those equal to or greater than 1.0 pCi/m³ are reported to two significant figures. For averaging purposes individual concentration values less than the minimum detectable concentration (~0.03 pCi/m³ for a 700 m³ sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are as follows:

Concentration (pCi/m³)	Reported value of concentration above MDC (pCi/m³)	Reported value of concentration below MDC (pCi/m³)
<0.05	<0.1	<0.1
≥0.05 <0.15	0.1	<0.1
≥0.15	As calculated and rounded	< calculated MDC

As shown by table 2, the highest gross beta concentration at stations within the network was 2.7 pCi/m³ at Bishop, Calif., during June 7–10, 1974.

From gamma spectrometry results, fission products in varying combinations of zirconium-95, ruthenium-106 and cerium-144 were identified on filters collected throughout the network. The maximum concentrations (pCi/m³) of these radionuclides were as follows: zirconium-95, 0.41 pCi/m³ at Bishop, Calif. on June 7–10; ruthenium-106, 0.62 pCi/m³ at Logan, Utah on June 26–28; and cerium-144, 0.83 pCi/m³ at Bishop, Calif. on June 19–21, 1974.

These radionuclides are attributed to seasonal variations in worldwide fallout. No radioactivity from the nuclear detonation by the Peoples Republic of China was detected. No radionuclides were identified by gamma spectrometry on any charcoal cartridges during June.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentration in air, June 1974

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	12	0.9	<0.1	0.4
	Phoenix	4	.3	.2	.2
	Seligman	12	.4	<.1	.2
	Winslow	5	.2	.1	.2
Ark:	Little Rock	5	.3	.1	.2
Calif:	Baker	16	.9	.2	.5
	Barstow	15	.9	.1	.4
	Bishop	12	2.7	.3	.8
	Death Valley Junction	13	.9	.2	.5
	Furnace Creek	11	1.0	.3	.6
	Indio	5	.4	.2	.3
	Lone Pine	16	.9	.2	.4
	Needles	6	.5	.2	.3
	Ridgecrest	12	.5	.2	.3
	Shoshone	12	1.3	.2	.4
Colo:	Denver	5	.8	.2	.4
	Durango	5	.5	.1	.2
Idaho:	Boise	5	.4	.3	.4
	Idaho Falls	4	.6	.2	.4
	Preston	6	.6	.3	.4
	Twin Falls	5	.5	.2	.4
Iowa:	Iowa City	5	.3	.1	.2
	Sioux City	4	.5	.3	.4
Kans:	Dodge City	4	.2	.1	.2
La:	Lake Charles	5	.4	.2	.3
	Monroe	5	.3	.1	.2
	New Orleans	6	.4	.2	.3
Minn:	Minneapolis	5	.4	.2	.3
Mo:	Clayton	5	.4	.1	.2
	Joplin	5	.3	.1	.2
	St. Joseph	4	.5	.1	.3
Nebr:	North Platte	6	.5	.2	.4
Nev:	Alamo	12	.6	.2	.3
	Austin	3	.5	.1	.4
	Battle Mountain	5	.6	.2	.4
	Beatty	12	.7	.2	.4
	Blue Eagle Ranch (Currant)	12	.7	.1	.4
	Blue Jay	12	.7	.1	.3
	Caliente	11	.7	.2	.4
	Currant Ranch	12	.6	.2	.4
	Currie	5	.4	.2	.3
	Diablo	12	.8	.2	.4
	Duckwater	10	.6	.1	.3
	Elko	5	.5	.2	.4
	Ely	8	.5	.1	.3
	Eureka	10	.5	.1	.4
	Fallini's Twin Springs Ranch	12	.6	<.1	.4
	Fallon	5	.6	.3	.5
	Geyser Ranch (Pioche)	2	.5	.3	.4
	Goldfield	10	1.7	.2	.5
	Groom Lake	12	.9	.2	.5
	Hiko	12	.7	.2	.4
	Indian Springs	12	.5	.1	.2
	Las Vegas	20	.9	.2	.4
	Lathrop Wells	12	.9	.2	.4
	Lida	7	.5	<.1	.2
	Lovelock	2	.4	.4	.4
	Lund	12	.6	.1	.4
	Mesquite	12	.6	.1	.3
	Nyala	12	.7	<.1	.4
	Pahrump	10	.6	.1	.3
	Pioche	12	.6	.2	.3
	Reno	5	.7	.4	.4
	Round Mountain	12	.9	.1	.4
	Scotty's Junction	12	.8	.2	.5
	Stone Cabin Ranch	12	.4	<.1	.2
	Sunnyside	12	.5	.1	.3
	Tonopah	11	.8	.2	.5
	Tonopah Test Range	9	.6	.2	.4
	Warm Springs	2	.6	.2	.3
	Warm Springs Ranch	10	.6	.1	.4
	Wells	5	.7	.2	.5
	Winnemucca	5	.5	.3	.4
N. Mex:	Albuquerque	5	.2	.2	.2
	Carlsbad	5	.4	<.1	.2
Oreg:	Burns	3	.4	.3	.4
S. Dak:	Aberdeen	5	.4	.2	.3
	Rapid City	5	.6	.2	.4
Tex:	Abilene	5	.4	.1	.3
	Austin	5	.3	.1	.2
	Fort Worth	5	.3	<.1	.2
Utah:	Bryce Canyon	10	.6	.1	.2
	Cedar City	8	.5	.1	.3
	Delta	12	.4	.1	.2
	Dugway	5	.5	.2	.4
	Enterprise	5	.4	.2	.3
	Garrison	12	.5	.2	.4
	Logan	5	1.2	.1	.5

Table 2. Summary of gross beta radioactivity concentration in air, June 1974—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Utah:	Milford	10	.5	.1	.2
	Monticello	5	.5	.1	.2
	Parowan	5	.4	.1	.2
	Provo	5	.8	.2	.4
	Salt Lake City	12	.7	.2	.4
	St. George	13	1.1	.1	.4
	Vernal	2	.3	.2	.2
	Wendover	4	.6	.3	.5
Wash:	Seattle	5	.2	<.1	.1
	Spokane	5	.3	.2	.3
Wyo:	Rock Springs	5	.5	.2	.3
	Worland	5	.7	.3	.4

3. Canadian Air and Precipitation Monitoring Program,[3] June 1974

Radiation Protection Bureau
Department of National Health and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for June 1974 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, June 1974

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	13	0.38	0.08	0.23	216.0	4.3
Coral Harbour	13	.24	.07	.16	56.0	2.5
Edmonton	13	.36	.15	.26	48.9	4.2
Ft. Churchill	14	.23	.01	.12	67.4	4.3
Fredericton	12	.17	.04	.11	65.7	4.4
Goose Bay	15	.17	.01	.09	27.5	1.6
Halifax	14	.24	.02	.13	59.3	5.3
Inuvik	10	.24	.02	.13	92.7	1.7
Montreal	14	.28	.05	.17	95.1	6.3
Moosonee	13	.28	.01	.15	NS	
Ottawa	13	.17	.03	.10	113.0	4.7
Quebec	15	.19	.08	.14	44.0	5.6
Regina	13	.93	.11	.52	100.2	2.3
Resolute	4	.09	.05	.07	150.7	2.2
St. John's, Nfld	2	.20	.02	.11	NS	
Saskatoon	12	.34	.07	.21	111.0	6.8
Sault Ste. Marie	11	.24	.02	.13	72.7	9.4
Thunder Bay	15	.25	.03	.14	89.5	9.1
Toronto	NS				21.2	2.8
Vancouver	12	.28	.04	.16	155.2	3.1
Whitehorse	13	.22	.01	.12	101.7	3.9
Windsor	NS				97.8	4.9
Winnipeg	15	3.11	.13	1.62	243.3	4.3
Yellowknife	15	.20	.17	.19	90.7	5.8
Network summary	281	3.11	0.01	0.23	96.3	4.5

NA, not available.
NS, no sample.

[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

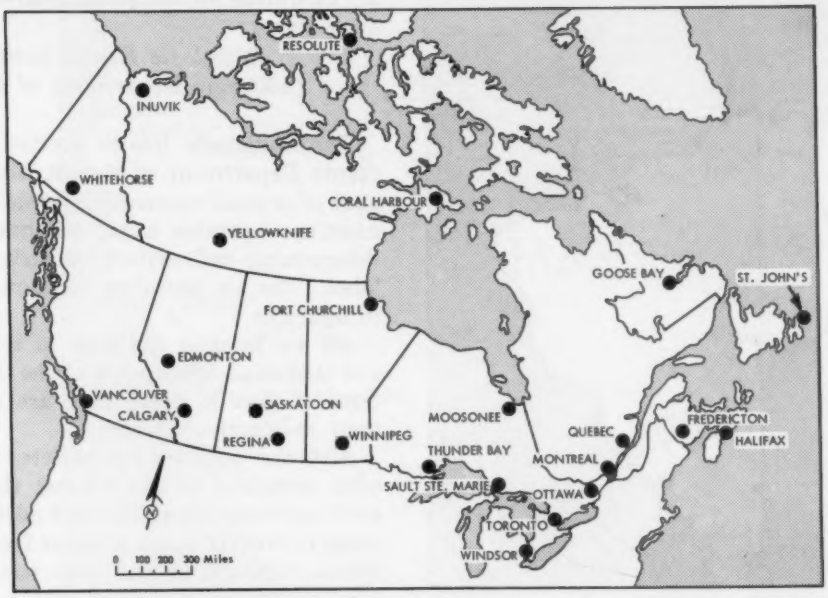

Figure 4. Canadian air and precipitation sampling stations

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4. Pan American Air Sampling Program, June 1974

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The June 1974 air monitoring results from the participating countries are given in table 4.

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, June 1974

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	0			
Chile:	Santiago	25	0.15	0.00	0.02
Colombia:	Bogota	18	.03	.00	.01
Ecuador:	Cuenca	1	.00	.00	.00
	Guayaquil	19	.02	.01	.01
	Quito	6	.00	.00	.00
Guyana:	Georgetown	1	.01	.01	.01
Jamaica:	Kingston	0			
Peru:	Lima	17	.01	.00	.01
Trinidad and Tobago:	Port of Spain	0			
Venezuela:	Caracas	0			
Pam American summary		87	0.15	0.00	0.01

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

5. California Air Sampling Program, June 1974

Radiologic Health Section
California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples then are composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the monthly gross beta radioactivity in air for June 1974.

Table 5. Gross beta radioactivity in California air, June 1974

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	22	1.36	0.14	0.70
Barstow	30	1.34	.18	.60
Berkeley	30	.63	.03	.26
Diablo Canyon Nuclear Power Plant	9	.47	.03	.23
El Centro	21	1.07	.11	.52
Eureka	22	.55	.06	.18
Fresno	19	1.13	.10	.57
Humboldt Bay Nuclear Power Plant	14	.39	.06	.17
Livermore	21	.82	.06	.35
Los Angeles	18	1.03	.06	.31
Rancho Seco Nuclear Power Plant	14	.93	.14	.45
Redding	17	1.78	.47	1.01
Sacramento	20	.74	.07	.31
Salinas	12	.40	.06	.22
San Bernardino	17	.73	.22	.46
San Diego	20	.56	.05	.28
San Luis Obispo	19	.52	.03	.26
San Onofre Nuclear Generating Station	5	.46	.21	.28
Summary	330	1.78	0.03	0.40

Figure 6. California air sampling program stations

6. Mexican Air Monitoring Program January–June 1974

Instituto Nacional de Energía Nuclear
México, D.F.

Until December 1971, the Radiation Surveillance Network of Mexico was operated by the Comision Nacional de Energía Nuclear (CNEN).

In December 1971, the CNEN became the Instituto Nacional de Energía Nuclear (INEN), as a result of a new law passed by Congress.

In the Instituto Nacional de Energía Nuclear, the Comité de Seguridad Radiológica (Radiological Security Committee) (CRS) is responsible for radiological protection. The Environmental Radioactivity Section (Sección de Radioactividad Ambiental) of the CSR is in charge of monitoring and measuring environmental radioactive contamination in general, including radiation in mines, uranium milling plant, and the Nuclear Center of Mexico.

Figure 7. Mexican air sampling locations

Table 6. Mexican gross beta radioactivity of airborne particulates. January-June 1974

Station	Gross beta radioactivity (pCi/m³)					
	Jan	Feb	Mar	Apr	May	June
Chihuahua:						
Maximum	0.10	0.25	0.34	0.24	0.30	0.57
Minimum	.08	.22	.10	.14	.22	.18
Average	(*)	(*)	(*)	.16	.26	.33
Ensenada:						
Maximum	NS	NS	.70	.47	.63	.33
Minimum	NS	NS	.17	.17	.14	.16
Average	NS	NS	.44	.35	.30	.24
Mérida:						
Maximum	.39	.44	.57	.20	.23	.31
Minimum	.07	.15	.16	.09	.09	.07
Average	.14	.27	.29	.12	.18	.19
México, D.F:						
Maximum	.16	.26	.36	NS	NS	.50
Minimum	.10	.18	.18	NS	NS	.09
Average	.12	.20	(*)	NS	NS	.25
Torreón:						
Maximum	.33	.32	.44	.28	.37	.41
Minimum	.05	.25	.18	.12	.17	.19
Average	.15	.28	.31	.22	.21	.27
Veracruz:						
Maximum	NS	NS	NS	NS	.19	.59
Minimum	NS	NS	NS	NS	.05	<.04
Average	NS	NS	NS	NS	.11	.20

* Average not calculated for less than 5 samples.
NS, no sample.

Since radioactivity in air particulates have decreased to very low levels in the past few years, the objective of the air monitoring program has been changed from an alert type of network to emphasize dose assessment.

Measurements will continue in the following 6 areas: México City, D.F., Chihuahua; Ensenada, Torreón; Veracruz, and Mérida (figure 7). The sampling and analysis procedures were described previously (*6*).

The maximum, minimum, and average beta radioactivity in surface air from January through June 1974 are presented in table 6. Statistically it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*7*).

(*6*) INSTITUTO NACIONAL DE ENERGIA NUCLEAR. Mexican air monitoring program, August–December 1970 and January 1971. Radiol Health Data Rep 12:525–528 (October 1971).

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ERAMS Plutonium and Uranium in Air Component, January-March 1974

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973 was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Plutonium and Uranium in Air Component is a restructuring of the Plutonium in Airborne Particulates network, which was comprised of monthly plutonium analyses from selected Radiation Alert Network sampling stations. The current sampling stations have been reoriented towards fuel processing, fuel reprocessing, and other facilities using plutonium or uranium. The Plutonium and Uranium in Air Component consists of 19 air sampling stations (figure 1) and are taken from the 19 continuously operated sampling stations of the ERAMS Gross Radioactivity and Deposition Component. Plutonium-238, plutonium-239, uranium-234, and uranium-238 analyses are performed on a quarterly composite from each of the 19 sampling stations by the Eastern Environmental Radiation Facility, Montgomery, Ala. The volume of the air sampled ranged generally between 25 000 to 40 000 m^3 for each quarterly composite sample analyzed. The results from January–March 1974 are shown in table 1. The minimum detectable activities are 20, 15, 15, and 15 fCi per sample for plutonium-238, plutonium-239, uranium-234, and uranium-238, respectively.

Other coverage in *Radiation Data and Reports:*

Period	Issue
January–March 1973	May 1974
April–June 1973	June 1974
July–September 1973	September 1974
October–December 1973	October 1974

Table 1. ERAMS Plutonium and Uranium in Air Component, January-March 1974

Sampling location		Concentration [a] ($aCi/m^3 \pm 2\sigma$)				($^{239}Pu/^{238}Pu$) [b]	Potential sources of plutonium or uranium
		^{234}U	^{238}U	^{238}Pu	^{239}Pu		
Ala:	Montgomery	15.2±1.3	12.8±1.2	0.3±0.2	19.7±1.9	62±31	Background
Calif:	Berkeley	7.9± .9	7.4± .8	2.0± .5	13.1±1.4	7± 2	General Electric Company San Jose, Calif. Lawrence Berkeley Laboratory Berkeley, Calif. Lawrence Livermore Laboratory Livermore, Calif.
	Los Angeles	19.0±1.6	20.4±1.7	1.9± .5	19.2±2.1	10± 3	Atomics International Canoga Park, Calif.
Colo:	Denver	101 ±6.4	108 ±6.8	2.6± .8	39.7±4.8	15± 5	Rocky Flats Plant Golden, Colo.
Idaho:	Idaho Falls	39.0±2.7	35.9±2.5	2.0± .5	16.2±1.8	8± 2	National Reactor Testing Station Idaho Falls, Idaho
Ill:	Chicago	(c)					Argonne National Laboratory Lemont., Ill. Midwest Fuel Reprocessing Plant Morris, Ill.
Nev:	Las Vegas	140 ±8.5	71.6±4.7	4.2± .9	18.0±2.3	4± 1	Nevada Test Site Las Vegas, Nev.
N. Mex:	Santa Fe	37.7±2.9	40.2±3.0	1.7± .5	26.2±2.8	15± 5	Los Alamos Laboratory Los Alamos, N. Mex.
N.Y:	Buffalo	70.7±4.7	70.0±4.6	2.2± .6	14.2±1.7	7± 2	Nuclear Fuel Services West Valley, N.Y.
	New York City	(c)					Gulf United Nuclear Fuels Pawling, N.Y.
N. Dak:	Bismarck	54.7±3.6	50.6±3.3	1.8± .5	14.3±1.6	8± 2	Background
Ohio:	Columbus [d]	90.7±5.9	91.6±6.0	.5± .2	13.8±1.5	26±12	Battelle Columbus Laboratory Columbus, Ohio Mound Laboratory Miamisburg, Ohio
Okla:	Oklahoma City	36.9±3.0	35.2±2.9	1.7± .5	24.1±2.6	14± 5	Kerr-McGee Cimarron Plant Cresent, Okla.
Oreg:	Portland	22.1±2.0	19.6±1.8	2.6± .5	11.1±1.2	4± 1	Hanford Laboratories Richland, Wash Exxon Nuclear Richland, Wash.
Pa:	Harrisburg [e]	24.6±2.5	24.4±2.4	1.3± .4	14.1±1.7	11± 4	Westinghouse Cheswick, Pa. NUMEC—Babcock & Wilcox Leechburgh, Pa.
S.C:	Anderson	(c)					Westinghouse Fuels Recycle Anderson, S.C. Savannah River Plant Aiken, S.C.
	Columbia	32.5±2.3	30.4±2.2	1.0± .3	15.9±1.6	17± 5	Allied Gulf Nuclear Fuel Services Barnwell, S.C.
Tenn:	Knoxville	(c)					NFS Fuels Fabrication Plant Erwin, Tenn. Oak Ridge National Laboratory Oak Ridge, Tenn. LMFBR Demo Site Oak Ridge, Tenn.
Va:	Lynchburg	(c)					Babcock & Wilcox Lynchburg, Va.
Average		49.4	44.2	1.8	18.5	15	

[a] Any concentration less than the 2σ error has been reported as zero.
[b] Ratio calculated from raw data before rounding.
[c] Station to be established.
[d] Station to be relocated to Cincinnati.
[e] Station to be relocated to Pittsburgh.

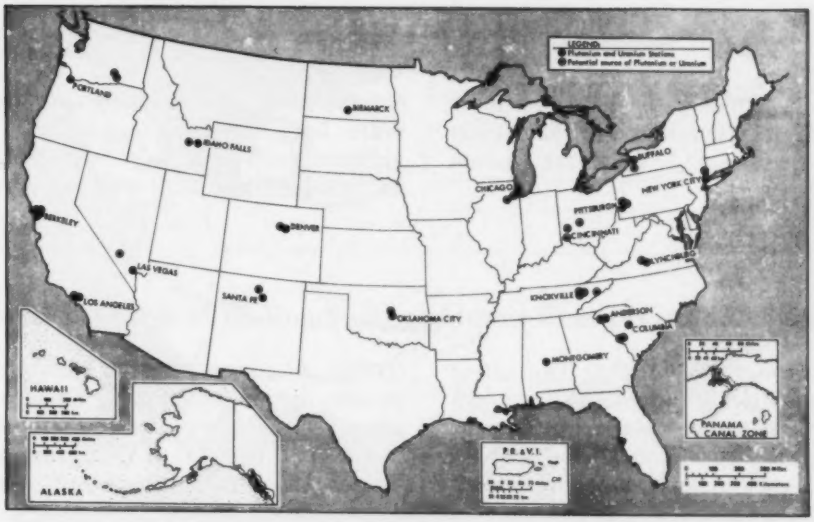

Figure 1. ERAMS Plutonium and Uranium in Air Component sampling locations

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ERAMS Krypton-85 in Air Component, January-June 1973

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS) was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

Krypton-85 is a long-lived noble gas with a half life of 10.8 years. It is released into the atmosphere by nuclear reactor operations, fuel reprocessing, and nuclear detonations. Krypton-85 also occurs naturally in minor quantities primarily from the neutron capture of stable krypton-84 as well as spontaneous fission and neutron-induced fission of uranium. The monitoring of krypton-85 in the atmosphere has been conducted by the Eastern Environmental Radiation Facility (EERF), Montgomery, Ala., to identify and establish baseline levels and long-term trends, and these results have been published (*1,2*).

The krypton-85 in air component began operating on a routine basis in January 1973 with sample collections and analyses being performed on a semiannual basis from 12 sampling locations (figure 1). These locations were selected to provide atmospheric coverage of the United States with considerations being given to the proximity to fuel reprocessing plants, nuclear reactors, and wide geographic coverage. Dry compressed air samples were purchased from commercial air suppliers and analyzed for krypton-85 by the method of Cummings (*3*). The minimum detectable concentration for krypton-85 is approximately 2 pCi/m^3. The results for January–June 1973 are shown in table 1.

Figure 1. ERAMS Krypton-85 in Air Component sampling locations

Table 1. Krypton-85 in air, January-June 1973

Location		Krypton-85 concentration (pCi/m³ at STP)[a]
Ala:	Montgomery	15.0
Calif:	Oakland	15.4
Fla:	Tampa	15.1
Ill:	Chicago	15.6
Mass:	Boston	14.3
Mich:	Detroit	14.9
N.J:	Camden	16.2
N.Y:	Buffalo	NS
	Utica	13.1
N.C:	Greensboro	15.8
Okla:	Oklahoma City	13.8
Oreg:	Portland	NS
Average		14.9

[a] Standard temperature and pressure.
NS, no sample.

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(*3*) CUMMINGS, S. L., R. L. SHEARIN, and C. R. PORTER. A rapid method of determining ^{85}Kr in environmental air samples. Proceedings of the International Symposium on Rapid Methods for Measurement of Radioactivity in the Environment (1971), pp. 163–169.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the levels of environmental contaminants including radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required. The complete environmental monitoring reports are available from local AEC operations offices or from the National Technical Information Services at a nominal cost. The portions of these reports dealing with radioactivity are summarized for *Radiation Data and Reports*. Statements interpreting the radioactivity data are those of the USAEC contractors. The units for the data as reported in the individual reports have been converted from the format required by the AEC to that used by *Radiation Data and Reports*. The Environmental Protection Agency has not independently nor critically reviewed the data nor the conclusions derived therefrom.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Lawrence Livermore Laboratory and the National Reactor Testing Station.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Livermore Laboratory[2] January-December 1972

University of California
Livermore, Calif.

The Lawrence Livermore Laboratory (LLL) (figure 1) is located approximately 8 kilometers southeast of San Francisco in the Livermore Valley of California. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Prevailing winds are from the west and southwest during April through September. During the remainder of the year, winds from the northeast occur almost as frequently as those from the west and southwest. Annual rainfall is about 14 inches with most of the precipitation occurring during storms in the winter months. Surface water drainage from the valley is from east to west through various arroyos, with overflow near Sunol in the southwestern corner of the valley.

The Livermore Laboratory occupies a 2.5 square kilometer area approximately 5 kilometers east of the city of Livermore.

The laboratory plays an integral part in the nation's nuclear weapons development program and makes diversified researches into controlled thermonuclear reactions, industrial

[2] Summarized from Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, Lawrence Livermore Laboratory, January–December 1972.

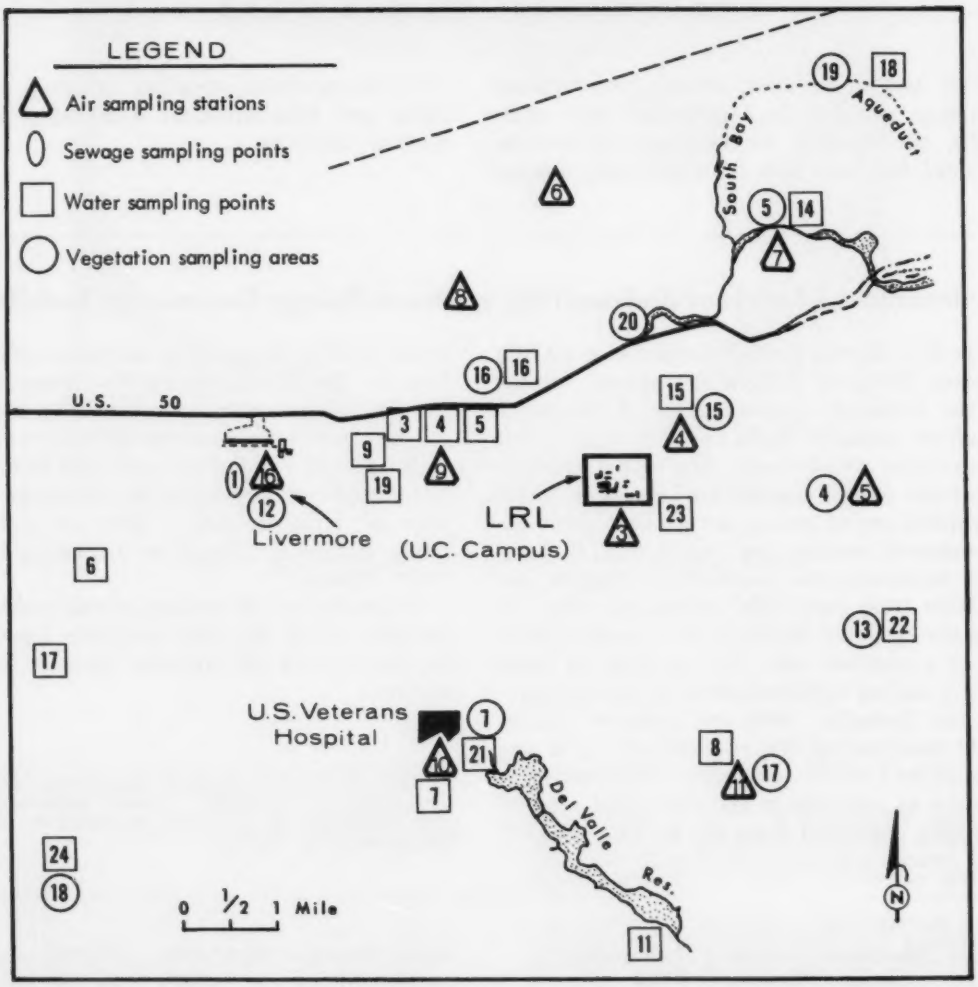

Figure 1. Lawrence Livermore Laboratory offsite environmental sampling locations

applications of nuclear explosives, and the effects of radiation on the biosphere.

Much of the materials testing and high-explosive diagnostic work of the laboratory is carried on at Site 300, a 26 km² area located about 21 km southeast of Livermore in the sparsely populated hills of the Diablo range which separates the Livermore and San Joaquin Valleys.

In order to carry out these programs, the laboratory handles a variety of potentially hazardous radioactive materials. A strict effluent control program, which places maximum emphasis on controlling the effluents at the source, has been in continuous existence since the laboratory began operation. An environmental surveillance program is conducted to ensure that this effluent control program is indeed restricting the release of radioactivity from the Livermore Laboratory and Site 300 to concentrations below the standards set forth by the U.S. Atomic Energy Commission. This program employs techniques capable of detecting radioactivity at environmental background

levels. The program includes the collection of airborne particulates, soil, water, sewer effluent, vegetation, and milk samples. These samples are analyzed for gross radioactivities as well as for the activity of specific radionuclides of interest. In addition, environmental background radiation is measured at numerous locations in the vicinity of the Livermore Laboratory by means of thermoluminescent detectors.

The results of the analyses are provided in this report. When appropriate, maximum, minimum, and average concentrations are given. Error limits, when included, reflect the uncertainties in the analyses at the 95 percent confidence level due to counting statistics. An attempt has been made to assess the impact resulting from the observed environmental activity levels of artificially and naturally produced radionuclides by calculating the whole body or critical organ doses that may be delivered to an adult by the various radionuclides of interest. Thus, one may compare the dose received from man's activity with that received from natural sources.

Atmospheric radioactivity

The concentrations of various airborne radioactive substances were measured at 16 air sampling stations situated throughout the Livermore Valley. Their locations are shown in figures 1 and 2. The six samplers located on the laboratory perimeter use 520 cm^2 Whatman 41 filters. The average sampling rate is 0.70 m^3/min. The remaining samplers, located offsite, use 230 cm^2 HV–70 (cellulose-asbestos) filters and operate at an average flow rate of 0.1 m^3/min. These air samplers are situated in such a manner that they provide a reasonable assurance that a significant release of airborne particulate radioactivity from the laboratory would be detected regardless of the local meteorology at the time of the release. Filters are changed twice a week during the summer months to avoid excessive mass loading and weekly during the balance of the year. An automatic radiation detection system with gas-flow proportional detectors was used to determine gross alpha and beta activities deposited on the filters after radon-thoron daughter decay. The filters are also assayed for gamma-emitting radionuclides by means of a specially designed Ge(Li) detector equipped with a Compton suppression system (*1*).

No gross alpha activity above the 1.0 fCi/m^3 detection limit was observed on the filters. The gross beta activities averaged over 6-month periods and the annual average radioactivities are shown for each sampling location in table 1, where they may be compared with the appropriate AEC standards. A significant fraction of the beta activities deposited on the filters is due to global fallout produced by nuclear weapons tests and by cosmic-ray interactions with the atmosphere. This is shown in table 2 which lists the activities of the more abundant gamma-emitting radionuclides in monthly composite samples collected by the six laboratory perimeter samplers. These data do not exhibit the typical spring increase in surface air radioactivity observed in previous years. The increased activity during January may possibly be due to a Chinese atmospheric nuclear weapon test detonated in January 1972.

These monthly composite samples were also subjected to plutonium and uranium analyses by dry ashing and complete dissolution of the filters and subsequent radiochemical separation of the elements. The plutonium was isolated by ion-exchange techniques and detected by alpha spectrometry. The isotopic uranium analyses were performed by mass spectrographic methods. The results are provided in table 3. Inspection of the data reveals that the relative activities of plutonium-238 and plutonium-239 approximate those normally observed in global fallout. The uranium-235 to uranium-238 ratios are somewhat lower than the natural uranium ($^{235}U/^{238}U = 7.25 \times 10^{-3}$). Airborne maximum concentrations are well below the guide levels for each isotope.

The calculated annual lung doses to an adult resulting from inhalation of the radionuclides listed in tables 2 and 3 are shown in table 4, indicate that manmade radiation provides a minor additional exposure, the largest fraction being from cerium-144 in global fallout (250 μrem). These lung doses were obtained by using the ICRP Lung Model (*2*), and making

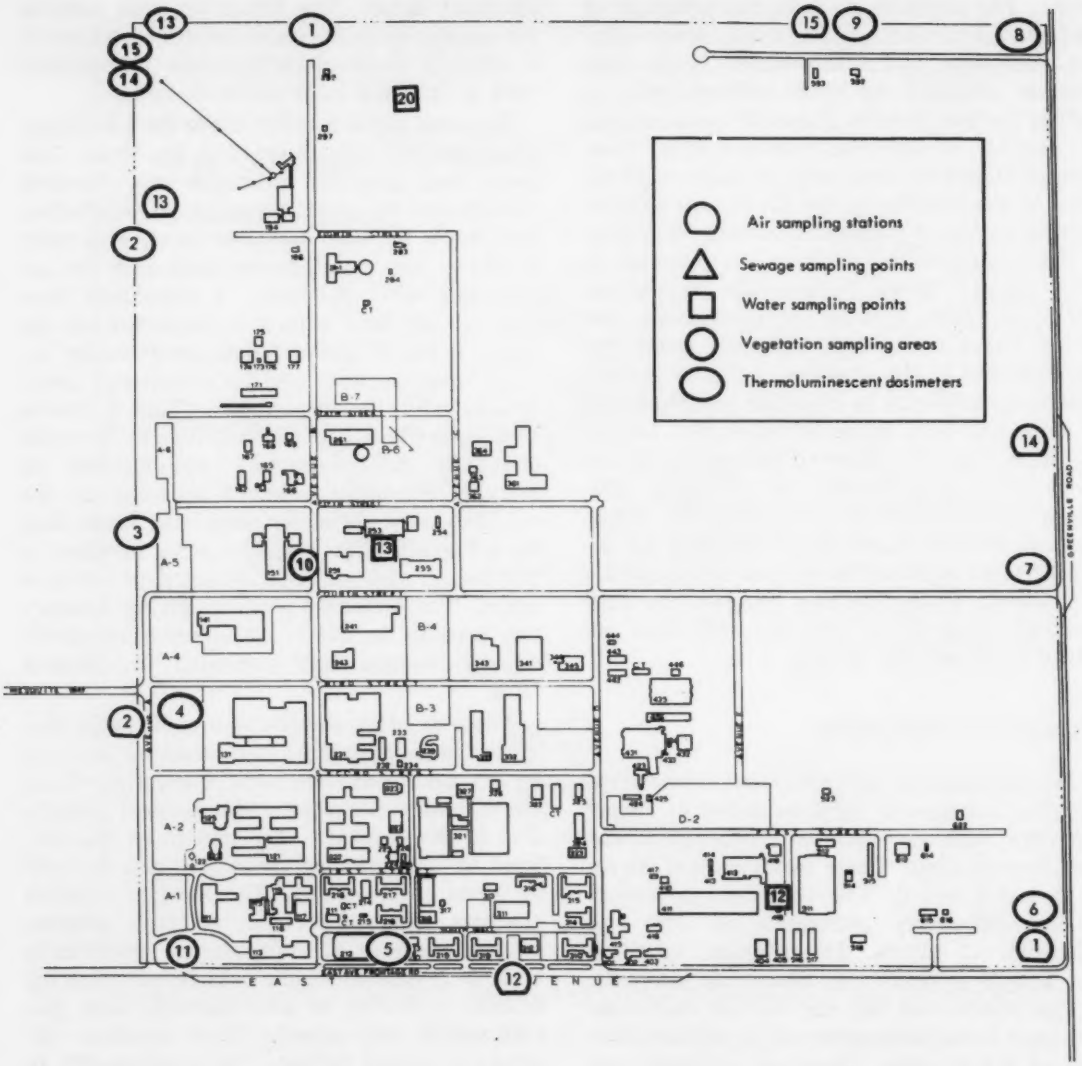

Figure 2. Lawrence Livermore Laboratory onsite environmental sampling locations

the following assumptions:

the radionuclides are present in an insoluble form,

the mean particle activity diameter is 1 micrometer, and

the activities of the radionuclides within the various body organs have obtained equilibrium.

We feel the first two assumptions are reasonable in view of the fact that the activities may be situated in insoluble silicate matrixes within particles that may range in size from 0.1 to several micrometers in diameter. This is the range usually observed in air pollution studies. Also, since global fallout has been with

Table 1. Airborne particulate radioactivity within the Livermore Valley, January-December 1972

Sampling location [a]	Gross beta radioactivity (fCi/m³)									Percent AEC standard [b]
	Number of samples	January–June 1972			Number of samples	July–December 1972			Annual average	
		Maximum	Minimum	Average		Maximum	Minimum	Average		
1	27	600 ±2%	19 ± 7%	96	33	130 ±4%	10 ±15%	47	72	7
2	33	350 ±5%	22 ± 7%	82	33	150 ±3%	12 ±20%	49	66	7
3	25	260 ±3%	13 ±14%	70	23	120 ±5%	10 ±32%	33	52	5
4	24	720 ±1%	23 ±13%	120	17	130 ±5%	18 ±20%	67	94	9
5	22	360 ±3%	17 ±16%	96	16	150 ±4%	6.9 ±46%	60	78	8
6	23	290 ±3%	8.2 ±19%	90	22	120 ±6%	5.7 ±55%	48	69	7
7	22	300 ±4%	5.9 ±49%	64	20	98 ±7%	9.7 ±33%	44	54	5
8	24	190 ±5%	7.1 ±37%	77	24	90 ±7%	8.4 ±39%	39	58	6
9	22	440 ±3%	16 ±12%	98	18	140 ±5%	16 ±22%	67	83	8
10	23	450 ±3%	14 ±13%	84	20	150 ±3%	8.4 ±39%	47	66	7
11	25	440 ±3%	8.3 ±19%	84	19	100 ±7%	4.9 ±63%	40	62	6
12	32	690 ±1%	11 ±16%	110	31	140 ±5%	9.2 ±14%	53	82	8
13	33	360 ±1%	19 ± 8%	110	33	150 ±3%	8.7 ±32%	55	83	8
14	33	680 ±1%	24 ± 7%	130	32	140 ±5%	16 ±20%	57	94	9
15	33	450 ±2%	21 ± 8%	120	33	160 ±4%	14 ±14%	56	88	9
16	25	360 ±3%	8.8 ±18%	82	32	110 ±6%	18 ±21%	50	66	7

[a] See figures 1 and 2 for sampling locations.
[b] The AEC standard is 1 pCi/m³.

Table 2. Results of gamma-ray spectral measurements of Livermore Laboratory perimeter air filters January-December 1972

Month (1972)	Concentration (fCi/m³)							
	Cerium-144	Cerium-141	Antimony-125	Beryllium-7	Ruthenium-103	Ruthenium-106	Cesium-137	Zirconium-95
January	28 ±10%	44 ± 6%	2.3 ± 64%	170 ± 8%	34 ± 6%	2.9 ± 34%	2.4 ±34%	21 ±16%
February	15 ± 8%	4.4 ± 20%	.40 ±100%	100 ± 8%	6.0 ±16%	.44 ± 86%	1.6 ± 4%	3.2 ± 2%
March	11 ± 6%	.75 ± 46%	.55 ± 54%	65 ±72%	.29 ±96%	.38 ± 46%	1.2 ±16%	.83 ±18%
April	19 ± 4%	14 ± 4%	1.4 ± 30%	120 ± 4%	6.4 ± 8%	.32 ± 64%	2.4 ±12%	19 ± 6%
May	31 ± 8%	30 ± 6%	2.1 ± 76%	150 ±10%	19 ±12%	.88 ± 42%	3.2 ±22%	44 ±10%
June	20 ± 6%	18 ± 4%	1.2 ± 44%	95 ± 6%	18 ± 6%	.52 ± 56%	2.2 ±16%	26 ± 8%
July	17 ± 6%	14 ± 3%	1.5 ± 33%	98 ± 5%	17 ± 5%	.80 ± 35%	1.9 ±16%	15 ± 8%
August	12 ± 6%	5.7 ± 8%	.68 ± 54%	110 ± 5%	9.4 ± 8%	4.0 ± 36%	1.7 ±16%	6.3 ±16%
September	10 ± 7%	2.9 ± 10%	.62 ± 60%	150 ± 4%	4.4 ±10%	.57 ± 35%	1.8 ±14%	4.2 ±18%
October	8.1 ±11%	.90 ± 42%	.64 ± 84%	250 ± 4%	2.2 ±20%	.54 ± 52%	1.5 ±21%	3.5 ±26%
November	3.5 ±14%	.76 ± 57%	.61 ± 45%	170 ± 4%	.87 ±45%	.14 ±100%	.68 ±24%	.96 ±18%
December	2.4 ±35%	.17 ±100%	.41 ± 45%	120 ± 6%	.29 ±89%	.18 ±100%	.63 ±46%	.49 ±29%
Annual average	15	11	1.0	130	9.8	0.97	1.8	14
AEC standard [a]	2×10^{5}	5×10^{4}	9×10^{5}	4×10^{7}	3×10^{4}	2×10^{5}	5×10^{5}	1×10^{4}
Percent AEC standard	0.0074	0.00022	0.00011	0.00033	0.00033	0.00049	0.00035	0.0014

[a] Assumes the activity is in an insoluble form.

us for upwards of two decades, the third assumption should be valid for most radionuclides since their half-lives in the lung are short relative to the long exposure time.

Soil

The laboratory's soil sampling program was upgraded during 1971 to include a determination of distribution of various radionuclides that have been deposited within the Livermore Valley as a result of global fallout from atmospheric weapons tests as well as from possible laboratory effluents. A core sampling method was used to obtain the soil samples at various depths down to 25 cm. Each sample was collected over a surface area of about 300 cm^2 by combining a minimum of 10 separate cores obtained over an approximate 250 m^2 area.

The samples were thoroughly dried and homogenized before undergoing analyses for the radionuclides of interest. One-hundred-

Table 3. Plutonium and uranium concentrations in air at Livermore Laboratory perimeter, January-December 1972

Month (1972)	Activity (aCi/m³)		$^{238}Pu/^{239}Pu$	Mass (pg/m³)		$^{235}U/^{238}U$[a]
	^{238}Pu	^{239}Pu		^{238}Pu	^{239}Pu	
January	1.4 ±19%	25± 7%	0.056	0.38 ±2%	65±4%	0.0058
February	1.5 ±21%	24± 8%	.062	.41 ±1%	130±2%	.0032
March	1.6 ±10%	17± 6%	.094	.27 ±2%	53±3%	.0051
April	3.5 ± 5%	35± 4%	.10	.33 ±2%	48±3%	.0069
May	4.2 ± 6%	45± 3%	.093	.63 ±2%	89±3%	.0071
June	3.3 ±12%	39± 6%	.085	.92 ±2%	130±3%	.0071
July	2.4 ±12%	36± 6%	.067	1.1 ±1%	130±2%	.0085
August	3.8 ± 9%	58± 6%	.067	1.4 ±1%	220±2%	.0064
September	3.9 ±10%	48± 6%	.079	1.6 ±1%	250±2%	.0064
October	2.4 ±16%	33± 7%	.073	.34 ±1%	54±2%	.0063
November	.51±27%	11± 9%	.046	.16 ±1%	29±2%	.0055
December	1.2 ±25%	12±10%	.10	.019±1%	36±2%	.0053
Annual average	2.5	32		0.63	100	
AEC standard[b]	1.0×10^{4}	1.0×10^{4}		1.9×10^{8}	1.5×10^{7}	
Percent of AEC standard	0.00025	0.0032		0.000033	0.00067	

[a] The $^{235}U/^{238}U$ ratio in natural uranium is 0.00725.
[b] Assumes the activity is in an insoluble form.

Table 4. Average annual integrated inhalation radiation doses at air concentrations shown in tables 2 and 3

Radionuclide	Calculated annual lung dose (μrem)
Cerium-144	250
Cerium-141	26
Antimony-125	34
Beryllium-7	27
Ruthenium-103	34
Ruthenium-106	17
Cesium-137	9.2
Zirconium-95	91
Plutonium-238	1.8
Plutonium-239	22
Uranium-235	2.0
Uranium-238	44

gram aliquots of samples were subjected to complete acid dissolution for the analysis of plutonium-238, plutonium-239, and strontium-90 by radiochemical techniques. Gamma spectral analyses were made by placing approximately 300 grams of soil on a Ge(Li) detector equipped with a Compton suppression system. These analyses provided quantitative data regarding the concentrations of artificially produced cesium-137 and the naturally occurring potassium-40, lead-212, and bismuth-214 activities.

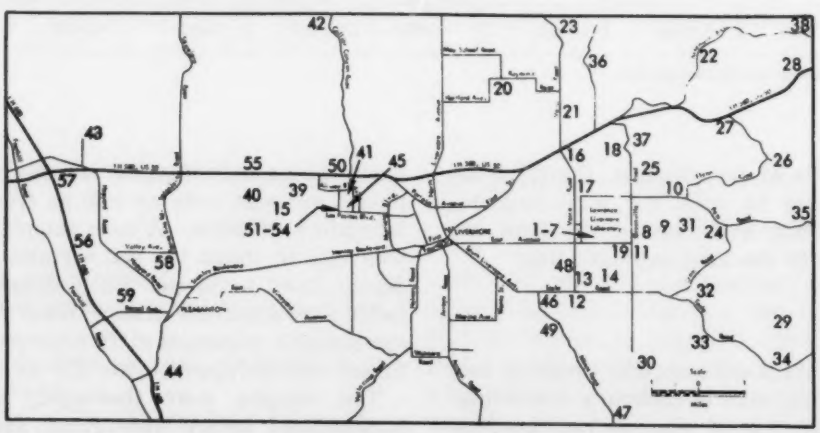

Figure 3. Livermore Valley soil sampling locations

Table 5. Activity levels of various radionuclides in soil, Lawrence Livermore, January-December 1972

Sampling location	Depth (cm)	Concentration (fCi/g)		
		Plutonium-238	Plutonium-239	Strontium-90
43	0–24		5.5 ± 5%	
44	0– 1		3.0 ±10%	
	0–24		3.2 ± 5%	
45	0– 5		360 ± 5%	68 ± 11%
	5–10		12 ± 5%	5.9 ± 86%
	10–15		9.0 ± 5%	11 ±118%
	15–25		1.2 ± 5%	11 ± 94%
46	0–25		2.6 ± 5%	67 ± 5%
47	0–25		1.8 ± 6%	61 ± 9%
48	0–25		2.2 ± 7%	62 ± 6%
49	0–25		2.5 ± 5%	68 ± 5%
50	0–25	.18 ±14%	2.8 ± 4%	92 ± 4%
51	0– 1	1.2 ± 8%	30 ± 4%	35 ± 15%
	1–25	2.6 ± 7%	100 ± 3%	13 ± 34%
52	0– 1	.72 ± 8%	5.9 ± 8%	30 ± 18%
	1–25	3.5 ± 9%	98 ± 5%	17 ± 23%
53	0– 1	1.8 ± 8%	16 ± 4%	
	1–25	13 ± 4%	220 ± 3%	29 ± 18%
54	0– 1	1.6 ± 7%	18 ± 4%	
	1–25	14 ± 5%	420 ± 4%	
55	0–30	.14 ±15%	3.5 ± 4%	57 ± 8%
56	0–25	.59 ±11%	9.3 ± 4%	
57	0–25	.14 ±15%	2.1 ± 4%	
58	0–25	.23 ±12%	7.6 ± 3%	
59	0–25	.14 ±14%	2.6 ± 4%	66 ± 7%
60	0–25	.10 ±30%	4.8 ± 8%	7.1 ± 39%
61	0–25	.91 ±20%	29 ± 7%	
62	0–25	.40 ±18%	15 ± 6%	18 ± 23%
63	0– 1	.59 ±17%	14 ± 7%	260 ± 7%
	1– 5	.45 ±19%	8.9 ± 7%	170 ± 6%
	5–10	.36 ±15%	12 ± 5%	140 ± 4%
	10–15	.18 ±19%	7.1 ± 6%	95 ± 5%
	15–20	.091 ±24%	2.7 ± 5%	43 ± 9%
	20–25	.091 ±24%	4.0 ± 7%	30 ± 12%
64	0–25	.30 ±28%	4.3 ±10%	
65	0–25	.30 ±24%	6.6 ± 8%	110 ± 14%
66	0– 1	.40 ±24%	8.5 ± 8%	93 ± 6%
	1– 5	.20 ±27%	5.4 ± 9%	81 ± 6%
	5–10	.20 ±26%	8.3 ± 7%	86 ± 7%
	10–15	.10 ±26%	3.4 ± 7%	60 ± 8%
	15–20		1.9 ±13%	16 ± 18%
	20–25		1.6 ±13%	7.3 ± 7%
67	0–25	.22 ±30%	2.6 ±10%	32 ± 9%
68	0– 1	.23 ±28%	8.3 ± 8%	
	1– 5	.32 ±23%	5.7 ± 8%	
	5–10	.23 ±26%	4.9 ± 8%	
	10–15	.045 ±40%	3.5 ± 9%	
	15–20		1.4 ±22%	
	20–25		1.3 ±19%	
69	0–25	1.0 ±17%	9.6 ± 6%	
70	0–25	.60 ±19%	7.2 ± 6%	49 ± 5%
71	0–25	.20 ± 7%	15 ± 7%	
72	0–25	.40 ±17%	6.0 ± 7%	
73	0–25	.30 ±28%	6.1 ± 9%	42 ± 9%
74	0–25		1.9 ±10%	53 ± 10%
75	0–25		2.6 ± 9%	
76	0–25		2.5 ± 9%	
77	0–25		2.3 ± 9%	
78	0–25	.20 ±18%	1.5 ±10%	
79	0–25		6.3 ± 7%	19 ± 15%
80	0–25		3.6 ±10%	
81	0–25	.45 ±37%	1.9 ±11%	
82	0–20		3.4 ± 9%	95 ± 4%
83	0–25		1.1 ±12%	
84	0– 1		3.1 ±14%	
	1– 5		2.4 ±13%	
	5–10		1.6 ±16%	
	10–15		2.4 ±16%	
	15–20		1.1 ±11%	
	20–25		2.0 ±10%	
85	0–25		1.7 ± 6%	
86	0–25		.84 ±14%	
87	0–25		1.6 ±13%	53 ± 12%
88	0–20		4.9 ± 8%	
89	0–25		2.3 ± 9%	
90	0–25		2.3 ±10%	
91	0–25		1.7 ±13%	
92	0–20		1.1 ±10%	
93	0–25		.97 ±12%	
94	0–25		2.3 ± 9%	
95	0–25		2.2 ± 9%	
96	0–30		4.3 ± 8%	42 ± 10%
97	0–30	.40 ± 7%	9.1 ± 7%	35 ± 15%
98	0–30		2.8 ±11%	41 ± 20%
99	0–30		3.6 ±10%	55 ± 17%

Table 6. Activity levels of various gamma-emitting radionuclides in soil January-December 1972

Sampling location	Depth (cm)	Concentration (dry weight) (fCi/g)			Potassium-40 (pCi/g dry weight)
		Cesium-137	Bismuth-214	Lead-212	
43	0– 1	580 ± 16%	450 ± 42%	530 ± 26%	11 ± 22%
	0–25	230 ± 40%	280 ± 57%	570 ± 22%	7.9 ± 24%
44	0– 1	320 ± 18%	240 ± 79%	450 ± 29%	3.5 ± 23%
	0–25	71 ± 64%	280 ± 50%	490 ± 22%	10 ± 20%
45	0– 5	310 ± 20%	440 ± 36%	650 ± 18%	9.9 ± 10%
	5–10	42 ± 80%	440 ± 36%	660 ± 17%	9.5 ± 20%
	10–15	58 ± 62%	500 ± 34%	710 ± 17%	9.6 ± 20%
	15–25	46 ± 71%	490 ± 35%	700 ± 17%	12 ± 18%
46	0– 1	94 ± 41%	430 ± 40%	510 ± 23%	8.1 ± 24%
	0–25	190 ± 29%	450 ± 40%	660 ± 19%	9.4 ± 17%
47	0–25	110 ± 43%	400 ± 44%	550 ± 22%	8.8 ± 17%
48	0–25	30 ± 90%	520 ± 29%	710 ± 15%	14 ± 14%
49	0– 1	680 ± 16%	300 ± 58%	480 ± 26%	5.6 ± 22%
	0–25	130 ± 32%	290 ± 55%	460 ± 25%	5.2 ± 20%
50	0–25	40 ± 98%	380 ± 42%	590 ± 19%	7.5 ± 22%
51	0– 1	110 ± 36%	390 ± 38%	640 ± 16%	9.5 ± 18%
	1–25	ND	330 ± 51%	580 ± 21%	11 ± 20%
52	0– 1	55 ± 74%	540 ± 31%	670 ± 18%	7.9 ± 24%
	1–25	24 ± 74%	540 ± 29%	670 ± 16%	7.9 ± 24%
53	0– 1	55 ± 62%	450 ± 32%	600 ± 17%	11 ± 16%
	1–25	240 ± 24%	630 ± 26%	640 ± 18%	13 ± 18%
54	0– 1	130 ± 34%	540 ± 32%	720 ± 17%	12 ± 20%
	1–25	28 ± 100%	540 ± 29%	730 ± 15%	14 ± 12%
55	0– 1	250 ± 20%	570 ± 27%	490 ± 22%	7.7 ± 16%
	1–25	73 ± 62%	290 ± 46%	530 ± 21%	10 ± 18%
56	0– 1	780 ± 14%	310 ± 64%	470 ± 36%	9.4 ± 22%
	1–25	100 ± 48%	440 ± 44%	720 ± 18%	10 ± 16%
57	0– 1	94 ± 44%	550 ± 32%	570 ± 21%	12 ± 13%
	1–25	20 ± 92%	430 ± 42%	710 ± 18%	12 ± 14%
58	0– 1	280 ± 18%	350 ± 46%	520 ± 22%	12 ± 12%
	1–25	94 ± 38%	410 ± 35%	570 ± 18%	9.2 ± 18%
59	0– 1	170 ± 26%	370 ± 43%	660 ± 16%	10 ± 13%
	1–25	83 ± 52%	390 ± 42%	540 ± 21%	10 ± 22%
60	0– 1	11 ± 100%	520 ± 30%	540 ± 20%	10 ± 14%
	1–25	63 ± 100%	390 ± 41%	700 ± 16%	9.6 ± 14%
61	0– 1	34 ± 100%	750 ± 30%	980 ± 15%	12 ± 16%
	1–25	57 ± 38%	730 ± 22%	900 ± 12%	12 ± 11%
62	0– 1	130 ± 30%	490 ± 32%	580 ± 19%	12 ± 12%
	1–25	52 ± 72%	350 ± 46%	580 ± 19%	8.3 ± 17%
63	0– 1	370 ± 19%	580 ± 30%	490 ± 24%	9.8 ± 16%
	1– 5	460 ± 18%	780 ± 28%	890 ± 17%	14 ± 15%
	5–10	360 ± 21%	640 ± 35%	770 ± 20%	15 ± 15%
	10–15	200 ± 27%	620 ± 32%	820 ± 17%	14 ± 12%
	15–20	36 ± 100%	640 ± 30%	860 ± 15%	14 ± 12%
	20–25	28 ± 100%	580 ± 37%	790 ± 19%	12 ± 14%
64	0– 1	770 ± 10%	450 ± 34%	580 ± 18%	11 ± 12%
	1–25	130 ± 34%	450 ± 36%	500 ± 22%	10 ± 15%
65	0– 1	380 ± 16%	550 ± 29%	570 ± 19%	10 ± 18%
	1–25	190 ± 26%	390 ± 37%	540 ± 19%	11 ± 10%
66	0– 1	230 ± 24%	290 ± 54%	530 ± 21%	8.3 ± 18%
	1– 5	180 ± 26%	480 ± 32%	540 ± 19%	11 ± 12%
	5–10	210 ± 24%	440 ± 34%	530 ± 20%	12 ± 12%
	10–15	89 ± 36%	440 ± 29%	450 ± 20%	10 ± 10%
	15–20	19 ± 88%	430 ± 29%	500 ± 17%	11 ± 10%
	20–25	51 ± 62%	480 ± 31%	510 ± 19%	12 ± 12%
67	0– 1	720 ± 10%	390 ± 36%	430 ± 23%	8.0 ± 18%
	1–25	36 ± 73%	260 ± 47%	350 ± 23%	8.1 ± 12%
68	0– 1	290 ± 20%	460 ± 34%	490 ± 22%	7.3 ± 16%
	1– 5	300 ± 18%	530 ± 29%	570 ± 18%	8.2 ± 14%
	5–10	290 ± 18%	480 ± 31%	520 ± 19%	.74 ± 14%
	10–15	90 ± 38%	470 ± 30%	580 ± 17%	7.5 ± 14%
	15–20	43 ± 66%	570 ± 23%	560 ± 16%	8.0 ± 8%
	20–25	21 ± 58%	560 ± 23%	520 ± 17%	8.8 ± 12%
69	0– 1	270 ± 13%	300 ± 54%	530 ± 21%	8.6 ± 18%
	1–25	110 ± 34%	440 ± 33%	540 ± 19%	8.0 ± 15%
70	0– 1	570 ± 12%	480 ± 34%	470 ± 23%	9.9 ± 14%
	1–25	100 ± 40%	260 ± 58%	490 ± 21%	9.6 ± 15%
71	0– 1	60 ± 61%	560 ± 30%	720 ± 16%	10 ± 14%
	1–25	56 ± 61%	570 ± 28%	660 ± 16%	11 ± 13%
72	0– 1	580 ± 16%	600 ± 36%	700 ± 21%	11 ± 17%
	1–25	90 ± 41%	710 ± 25%	810 ± 15%	12 ± 12%
73	0– 1	410 ± 17%	650 ± 31%	780 ± 18%	11 ± 15%
	1–25	69 ± 60%	850 ± 22%	890 ± 14%	11 ± 14%
74	0– 1	150 ± 15%	470 ± 34%	530 ± 20%	13 ± 13%
	1–25	63 ± 49%	510 ± 31%	430 ± 25%	11 ± 12%
75	0– 1	330 ± 21%	660 ± 30%	710 ± 18%	10 ± 17%
	1–25	110 ± 45%	360 ± 49%	820 ± 15%	11 ± 15%
76	0– 1	540 ± 12%	390 ± 41%	670 ± 17%	11 ± 13%
	1–25	130 ± 37%	470 ± 39%	660 ± 18%	11 ± 14%
77	0– 1	260 ± 24%	350 ± 52%	470 ± 27%	7.4 ± 20%
	1–25	120 ± 40%	450 ± 39%	500 ± 24%	8.8 ± 17%
78	0–25	ND	450 ± 33%	460 ± 22%	7.1 ± 18%
79	0– 1	62 ± 58%	580 ± 28%	570 ± 20%	11 ± 13%
	1–25	47 ± 70%	580 ± 28%	620 ± 18%	12 ± 12%
80	0– 1	300 ± 22%	480 ± 40%	540 ± 25%	13 ± 14%
	1–20	120 ± 41%	690 ± 28%	580 ± 22%	11 ± 16%

See footnotes at end of table

Table 6. Activity levels of various gamma emitting radionuclides in soil January-December 1972—continued

Sampling location	Depth (cm)	Concentration (dry weight) (fCi/g)			Potassium-40 (pCi/g dry weight)
		Cesium-137	Bismuth-214	Lead-212	
81	0- 1	310 ± 16%	500 ± 31%	580 ± 18%	12 ± 12%
	1- 5	210 ± 22%	420 ± 35%	600 ± 19%	15 ± 10%
	5-10	150 ± 20%	490 ± 25%	590 ± 14%	15 ± 8%
	10-15	28 ± 82%	520 ± 23%	620 ± 14%	14 ± 8%
	15-20	22 ± 94%	520 ± 23%	620 ± 14%	14 ± 8%
	20-25	ND	430 ± 30%	560 ± 16%	13 ± 10%
82	0- 1	250 ± 19%	430 ± 38%	650 ± 17%	10 ± 13%
	1-20	180 ± 29%	530 ± 34%	630 ± 20%	8.9 ± 17%
83	0- 1	180 ± 32%	400 ± 50%	520 ± 27%	8.5 ± 19%
	1-25	200 ± 23%	310 ± 50%	530 ± 21%	9.3 ± 14%
84	0- 1	120 ± 32%	390 ± 38%	480 ± 22%	7.9 ± 16%
	1- 5	170 ± 22%	440 ± 32%	450 ± 21%	6.7 ± 15%
	5-10	91 ± 35%	390 ± 33%	500 ± 18%	8.6 ± 13%
	10-15	85 ± 40%	360 ± 38%	430 ± 23%	7.8 ± 15%
	15-20	50 ± 60%	440 ± 31%	480 ± 19%	7.9 ± 14%
	20-25	71 ± 52%	310 ± 48%	500 ± 21%	7.9 ± 16%
85	0- 1	400 ± 17%	510 ± 37%	580 ± 23%	11 ± 14%
	1-25	130 ± 30%	600 ± 27%	620 ± 18%	12 ± 12%
86	0- 1	73 ± 57%	500 ± 35%	590 ± 19%	12 ± 14%
	1-25	64 ± 58%	580 ± 29%	470 ± 23%	11 ± 17%
87	0- 1	110 ± 38%	500 ± 33%	580 ± 20%	9.2 ± 15%
	1-25	82 ± 42%	570 ± 27%	620 ± 17%	10 ± 13%
88	0-20	260 ± 19%	630 ± 25%	690 ± 15%	10 ± 13%
89	0- 1	170 ± 25%	410 ± 36%	500 ± 20%	8.8 ± 14%
	1- 5	120 ± 27%	410 ± 30%	480 ± 18%	8.5 ± 13%
	5-10	42 ± 80%	580 ± 29%	660 ± 17%	11 ± 13%
	10-15	53 ± 73%	370 ± 47%	470 ± 26%	8.7 ± 17%
	15-20	140 ± 36%	740 ± 27%	590 ± 21%	12 ± 15%
	20-25	110 ± 30%	310 ± 40%	370 ± 24%	8.0 ± 14%
90	0- 1	300 ± 18%	350 ± 44%	550 ± 20%	8.6 ± 15%
	1-25	78 ± 40%	390 ± 32%	430 ± 21%	7.5 ± 14%
91	0- 1	100 ± 36%	540 ± 25%	650 ± 16%	13 ± 11%
	1-25	110 ± 35%	590 ± 27%	710 ± 15%	15 ± 10%
92	0- 1	120 ± 41%	570 ± 32%	650 ± 19%	8.4 ± 18%
	1-20	70 ± 62%	560 ± 33%	590 ± 21%	7.5 ± 19%
93	0- 1	68 ± 52%	630 ± 26%	560 ± 20%	11 ± 13%
	1-25	50 ± 77%	510 ± 35%	630 ± 19%	11 ± 14%
94	0- 1	1000 ± 11%	350 ± 56%	650 ± 22%	8.3 ± 20%
	1-25	93 ± 38%	440 ± 33%	620 ± 17%	6.6 ± 17%
95	0- 1	1200 ± 8%	450 ± 25%	370 ± 41%	9.6 ± 14%
	1-25	85 ± 50%	510 ± 21%	330 ± 48%	8.0 ± 18%

ND, nondetectable

The results of the analyses are provided in tables 5 and 6, and the sampling locations are shown in figure 3. The depth profile studies at sampling locations 63, 66, 68, and 84 indicate the artificially produced radionuclides to penetrate appreciably into the soil, probably as a result of leaching or mechanical mixing. As expected, the natural activities of potassium-40, lead-212, and bismuth-214 seem to be distributed fairly homogeneously with depth. Inspection of the data indicates that most of the activity in the soil is due to the naturally occurring radionuclides. On a concentration basis, the potassium-40 exhibits the highest values with lead-212 and bismuth-214 showing lesser values, but in general greater than those of the artificially produced radionuclides. Bismuth-214 and lead-212 are daughter products of uranium-238 and thorium-232, respectively.

The resulting deposition values of plutonium-238, plutonium-239, strontium-90 and cesium-137 are shown in table 7. Most of the plutonium-239 deposition levels are of the order of 1 nCi/m^2, and have resulted from global fallout, but some locations indicate values that are appreciably higher. For instance, elevated levels were exhibited by samples collected from the holding pond at the Livermore Sewage Treatment Plant represented by locations 45 and 51 through 54. These values have resulted from routine and accidental releases of small amounts of plutonium over long time periods through the sanitary sewer system which carries the laboratory's biological and industrial effluents to the Livermore Sewage Treatment Plant.

The median deposition level of strontium-90 within the Livermore Valley is 20 nCi/m^2. This

Table 7. Deposition levels of various radionuclides in soil, Lawrence Livermore, January-December 1972

Sampling location	Concentration (nCi/m²)			
	Plutonium-238	Plutonium-239	Strontium-90	Cesium-137
43		1.9		80
44		1.2		20
45		27	6.7	28
46		.91	23	67
47		.65	22	
48		.76	22	11
49		.87	24	58
50	0.063	.98	33	14
51	.88	34	5.1	
52	1.2	33	6.4	9.2
53	4.6	78		91
54	5.4	160		11
55	.057	1.5	25	29
56	.19	3.0		39
57	.044	.68		7.5
58	.079	2.7		36
59	.047	.90	24	30
60	.050	1.8	2.7	
61	.32	11		
62	.20	5.5	6.8	21
63	.068	2.0	29	47
64	.10	1.6		58
65	.10	2.8	45	83
66	.051	1.9	22	50
67	.10	1.3	15	30
68	.047	1.4		62
69	.20	3.6		43
70	.10	2.9	20	43
71	.090	5.9		22
72	.15	2.2		39
73	.12	2.2	15	28
74		.74	21	27
75		.92		41
76		.91		54
77		.81		44
78	.090	.62		
79		2.2	6.7	17
80		.99		36
81	.020	.78		29
82		.90	26	48
83		.38		70
84		.76		32
85		.61		48
86		.34		26
87		.58	20	33
88		1.5		78
89		1.0		36
90		.97		33
91		.64		42
92		.31		27
93		.36		19
94		.87		49
95		.87		49
96		1.9	19	
97	.18	3.2	16	
98		1.3	18	
99		1.6	25	

is about a factor of 4 less than the global fallout levels measured at many locations throughout the United States by the U.S. AEC Health and Safety Laboratory. Thus, the strontium-90 and cesium-137 deposition levels may readily be accounted for as being due to global fallout rather than laboratory contributed.

Environmental radiation levels due to the gamma-emitting radionuclides distributed in the soil may be calculated from table 7 using the data of Beck et al (*3*). The median exposure rate due to the cesium-137 activity found in Livermore Valley soils is approximately 0.1 μR/h (0.88 mR/yr). The total natural terrestrial exposure rate was also calculated for each sample from the potassium-40, bismuth-214 (uranium series) and lead-212 (thorium series) soil activities. These calculations showed a median exposure rate of 4.4 μR/h (38 mR/yr) with a range from 2.8 to 6.4 μR/h (25 to 56 mR/yr). When the approximately 4 μR/hr exposure rate from local cosmic radiation is added to these calculated terrestrial exposure rates, the totals are in good agreement with those obtained by TLD measurements.

Thus, the natural contribution to the exposure rate due to gamma emitters in the soil is far greater than that due to the artificially produced radionuclides. To determine the environmental impact due to the elevated plutonium deposition levels is very difficult. For these particular sites, the primary concern to man is that due to resuspension of the plutonium and subsequent inhalation. Since resuspension factors vary many orders of magnitude, it is difficult to calculate a meaningful expected airborne concentration. However, we anticipate that these airborne concentrations will be within the range of background levels.

Sewer effluent

The low level radioactive wastes from the laboratory are discharged into the City of Livermore sanitary sewer system. This effluent is processed at the Livermore Sewage Treatment Plant where the liquid and sludge are separated on entering the plant. The sludge passes into one of two digesters where it is broken down by bacterial action. Methane gas is evolved and burned, and the remaining sludge is released to large sludge ponds and retained for subsequent use as a soil conditioner. The purified water is used for irrigating the Livermore Golf Course and nearby agricultural land; the excess is discharged into the Los Positas Arroyo.

Weekly samples were collected from each digester, the aeration tank and the liquid effluent discharged from the plant in order to determine if any significant buildup of radioactivity occurred within the plant. After complete dissolution (using wet oxidation), the gross alpha and beta activities associated with these samples were determined by gas proportional counting. Tritium analyses were performed by subjecting 1 ml of each sample to direct liquid scintillation counting. In addition, a monthly composite sample of the effluent was analyzed for strontium-90 and plutonium-239 by radiochemical separation followed by beta and alpha counting, respectively. The concentrations observed during 1972 averaged over 1 month periods are given in tables 8, 9, and 10. Most of the gross alpha and gross beta activities are associated with the sludge present in the effluent. Thus, samples obtained from the digesters show the highest activities with the expected attendant decrease in activity as the relatively purified liquid passes through the aeration tank and is finally released from the plant.

Water

Water samples were collected from various locations in the Livermore Valley. These samples were analyzed for gross alpha and gross beta activities by techniques similar to those used for sewage effluent samples. No sample showed an alpha activity above the limit of sensitivity of 1.2 pCi/liter. Quarterly averages for beta activities are given in table 11. Loca-

Table 8. Livermore sewage treatment plant sampling results, 1972

Month (1972)	Gross alpha activity (pCi/liter)							
	Digesters				Aeration tank			
	Number of samples	Maximum	Minimum	Average	Number of samples	Maximum	Minimum	Average
January	8	690 ±26%	280 ± 42%	430	4	79 ±28%	35 ±46%	48
February	10	430 ±38%	81 ±54%	190	5	87 ±29%	52 ±43%	66
March	8	460 ±32%	150 ± 42%	280	4	170 ±20%	46 ±36%	98
April	8	360 ±32%	160 ± 35%	240	4	120 ±24%	51 ±34%	80
May	10	550 ±36%	160 ± 37%	250	5	120 ±24%	70 ±34%	86
June	8	1 500 ±30%	230 ± 35%	390	4	67 ±30%	13 ±30%	35
July	7	390 ±32%	88 ± 54%	220	3	70 ±33%	41 ±39%	51
August	10	470 ±28%	170 ± 37%	280	5	83 ±31%	58 ±39%	71
September	8	400 ±28%	170 ± 53%	330	4	56 ±31%	36 ±52%	43
October	10	290 ±35%	13 ±100%	200	5	61 ±34%	28 ±45%	50
November	8	740 ±30%	120 ± 60%	430	4	83 ±29%	58 ±36%	67
December	4	400 ±32%	260 ± 38%	330	2	92 ±28%	61 ±32%	77

Table 9. Livermore sewage treatment plant sampling results, January-December 1972

Month (1972)	Gross beta activity (pCi/liter)												
	Digesters				Aeration tank				Effluent				Percent AEC standard [a]
	Number of samples	Maximum	Minimum	Average	Number of samples	Maximum	Minimum	Average	Number of samples	Maximum	Minimum	Average	
January	8	2 300 ±10%	300 ±12%	800	4	61 ±6%	43 ± 8%	54	9	20 ±34%	8.5 ± 67%	14	14
February	10	670 ± 9%	220 ±14%	380	5	63 ±6%	40 ± 8%	53	11	18 ±37%	11 ± 56%	15	15
March	8	920 ± 7%	230 ±16%	420	4	81 ±5%	46 ± 7%	59	11	35 ±23%	7.2 ±100%	16	16
April	8	610 ±13%	270 ±13%	380	4	73 ±6%	55 ± 7%	64	11	20 ±33%	8.9 ±100%	14	14
May	10	750 ±15%	200 ±18%	390	5	66 ±6%	51 ± 7%	57	10	20 ±33%	7.4 ±100%	13	13
June	8	39 000 ± 1%	280 ±15%	10 000	4	53 ±7%	20 ±12%	40	8	15 ±42%	8.2 ±100%	11	11
July	6	4 000 ± 3%	210 ±18%	930	3	37 ±8%	36 ± 9%	37	11	19 ±38%	8.0 ± 71%	14	14
August	10	310 ±16%	230 ±19%	260	5	47 ±7%	36 ± 9%	41	10	17 ±41%	9.5 ± 64%	13	13
September	8	330 ±15%	240 ±16%	290	4	57 ±7%	41 ± 8%	47	12	21 ±33%	7.8 ±100%	13	13
October	10	330 ±14%	70 ±20%	230	5	60 ±6%	41 ± 8%	52	6	23 ±32%	11 ± 57%	16	16
November	8	8 000 ± 3%	250 ±17%	1 400	4	49 ±7%	44 ± 8%	46	11	61 ±17%	8.3 ±100%	14	14
December	4	400 ±14%	260 ±16%	320	2	52 ±7%	41 ± 8%	46	5	25 ±30%	8.6 ±100%	15	15

[a] AEC standard-100 pCi/liter.

Table 10. Livermore sewage treatment plant sampling results, January-December 1972

Month (1972)	Number of samples	Effluent (pCi/liter)							
		Tritium				Strontium-90		Plutonium-239	
		Maximum	Minimum	Average	Percent AEC standard [a]	Average	Percent AEC standard [b]	Average	Percent AEC standard [c]
January	9	3.0 ±33%	1.2 ±100%	1.5	0.050	[d]		[d]	
February	11	3.7 ±28%	1.2 ±100%	1.5	.050	1.2 ± 54%	0.40	[d]	
March	11	3.8 ±27%	1.2 ±100%	1.5	.050	.43 ± 54%	.14	1.0	0.020
April	11	63 ± 2%	1.2 ±100%	8.9	.30	.42 ± 72%	.14	.14	.0030
May	10	1.9 ±49%	1.2 ±100%	1.3	.040	.37 ±100%	.12	.11	.0020
June	8	7.4 ±15%	1.2 ±100%	2.4	.080	.88 ±100%	.29	.041	.00080
July	11	25 ± 5%	1.4 ± 77%	9.1	.030	.46 ±100%	.15	.0085	.00020
August	10	5.0 ±23%	1.3 ±100%	1.9	.060	1.1 ±100%	.37	.029	.00060
September	12	4.2 ±27%	1.2 ±100%	1.7	.060	.71 ±100%	.24	.023	.00050
October	6	6.4 ±17%	1.2 ±100%	2.1	.070	1.0 ± 60%	.33	[d]	
November	11	71 ± 2%	1.2 ±100%	8.7	.29	.94 ±100%	.31	.032	.00060
December	12	68 ± 2%	1.2 ±100%	10	.33	2.0 ± 50%	.67	[d]	
Annual average				4.2	.12	0.86	0.29	0.17	0.0030

[a] AEC standard (HTO) = 3 000 nCi/liter.
[b] AEC standard (strontium-90) = 300 pCi/liter.
[c] AEC standard (plutonium-239 soluble) = 5 000 pCi/liter.
[d] No analyses for these months.

Table 11. Gross beta activities in Livermore water samples, January-December 1972

Sampling location	Concentration (pCi/liter)							Annual average	Percent AEC standard *
	Number of samples	January–June 1972			Number of samples	July–December 1972			
		Maximum	Minimum	Average		Maximum	Minimum	Average	
11	6	5.4±27%	1.7± 65%	3.0	6	4.2±34%	2.5± 53%	3.1	3.1	10
12	6	3.2±39%	1.8± 68%	2.7	0					
13	6	3.8±38%	1.4±100%	2.3	3	2.7±47%	1.7±100%	2.2	2.2	7
15	6	4.9±28%	1.5±100%	3.1	5	5.4±29%	1.7± 69%	3.0	3.1	10
16	6	5.7±25%	3.5± 36%	4.7	6	6.3±25%	1.8± 68%	4.1	4.4	15
17	6	3.5±50%	1.7± 73%	2.6	6	2.9±46%	1.6±100%	2.3	2.5	8
18	6	5.7±26%	1.5±100%	3.4	0					
19	6	3.2±56%	1.5±100%	2.1	6	2.4±53%	1.5±100%	2.0	2.1	7
20	3	13 ±16%	7.3± 23%	9.8	3	6.7±25%	1.5±100%	4.8	7.3	24
21	6	5.4±64%	2.0± 64%	3.1	4	4.1±34%	1.6± 71%	3.2	3.2	11
22	6	12 ±16%	3.6± 39%	8.2	0					
23	6	6.0±25%	2.1± 60%	3.2	2	6.5±25%	3.3± 40%	4.9	4.1	14
24	6	5.0±38%	1.5±100%	3.1	2	8.2±22%	6.5± 25%	7.4	5.3	18

* AEC standard (beta activity), 30 pCi/liter.

tions 11, 15–18, and 21–24 represent surface sources such as ponds, creeks, reservoirs, and aqueducts. Livermore rainfall is sampled at location 20. The remainder of the locations represent domestic water sources. Gross beta activities are comparable to those observed during 1971. The highest activity was exhibited by the rainfall sample which is most likely due to its exposure to the relatively higher concentrations of the various natural and artificially produced radionuclides present in the atmosphere.

A number of these samples were analyzed for tritium activity. Because of the low activities, it was necessary to vacuum distill and electrolytically enrich the samples prior to liquid scintillation counting. The results of the analyses are shown in table 12. Inspection of the data indicates that the samples exhibit rather uniform tritium concentrations that are well below the AEC standards. The table also includes an estimate of the dose that may be delivered to an adult consuming water containing the listed tritium concentrations. The doses, which are typically less than 0.1 mrem, are based upon a daily water consumption of 1 liter per day (*4*) and the model of Anspaugh, *et al.* (*5*).

Table 12. Tritium activities in Livermore water samples, January-December 1972

Sampling location	Concentration (nCi/liter)							Annual average	Percent AEC standard *	Calculated annual adult whole body dose (μrem)
	Number of samples	January–June 1972			Number of samples	July–December 1972				
		Maximum	Minimum	Average		Maximum	Minimum	Average		
11	4	0.22± 6%	0.15 ± 5%	0.19	3	0.20± 7%	0.16 ± 10%	.019	0.19	0.0063	7.6
15	4	.22± 5%	.17 ±10%	.20	3	.20± 7%	.078 ± 18%	.16	.18	.0060	7.2
16	5	.35± 4%	.21 ± 6%	.29	3	.22± 7%	.11 ± 15%	.18	.23	.0076	9.2
17	4	.16±10%	.10 ±13%	.12	3	.15±11%	.11 ± 15%	.12	.12	.0040	4.7
18	4	.22± 7%	.17 ±10%	.19	0				.19	.0063	7.6
19	3	.19±10%	.062±13%	.12	3	.13±10%	.0070±100%	.080	.10	.0033	4.0
20	2	.39± 5%	.16 ± 8%	.28	2	.35± 5%	.34 ± 6%	.34	.31	.010	12
21	3	.27± 5%	.20 ± 5%	.23	2	.17±10%	.15 ± 8%	.16	.20	.0067	8.0
22	4	.34± 5%	.29 ± 7%	.30	0				.30	.010	12
23	3	1.9 ± 5%	.19 ± 5%	.80	2	.26± 8%	.21 ± 8%	.24	.52	.017	21
24	4	1.3 ±10%	.29 ± 4%	1.0	2	1.0 ± 2%	.60 ± 4%	.80	.90	.030	36

* AEC standard for tritium, 3 000 nCi/liter.

Table 13. Tritium activities in Livermore vegetation samples, January-December 1972

Sampling location	Tritium activity (nCi/liter)								Annual average	Calculated whole body dose (μrem)
	Number of samples	January–June 1972			Number of samples	July–December 1972				
		Maximum	Minimum	Average		Maximum	Minimum	Average		
4	6	0.83 ±24%	1.3 ± 58%	0.62	5	1.0 ±20%	0.19 ± 80%	0.67	0.65	8.4
5	6	6.1 ± 5%	2.1 ± 14%	3.3	5	15 ± 1%	1.3 ± 15%	2.2	2.7	40
7	6	.66 ±30%	.13 ±100%	.39	2	.31 ±66%	.17 ± 80%	.24	.31	4.7
10	6	2.8 ± 7%	.38 ± 67%	1.4	5	4.0 ± 6%	.72 ± 20%	2.3	1.9	28
11	6	7.6 ±12%	.53 ± 41%	2.7	5	1.7 ±15%	.66 ± 20%	1.2	2.0	30
12	6	1.9 ± 9%	.73 ± 31%	1.2	5	4.5 ± 4%	.80 ± 27%	2.6	1.9	28
13	6	.70 ±33%	.070 ±100%	.37	2	.55 ±38%	.30 ± 43%	.43	.40	6.0
15	6	2.2 ±11%	.11 ± 17%	1.2	5	3.3 ± 8%	.86 ± 18%	1.7	1.5	22
16	5	.69 ±28%	.33 ± 48%	.47	5	6.2 ±35%	.15 ±100%	.38	.43	6.5
17	6	.84 ±24%	.14 ±100%	.45	2	1.6 ±14%	.33 ± 39%	.95	.70	11
18	5	.48 ±46%	.21 ± 77%	.33	1			.53	.43	6.5
19	6	.64 ±34%	.13 ±100%	.30	4	15 ±15%	.21 ± 62%	.24	.27	4.0
20	6	29 ± 2%	.67 ±33 %	11	5	10 ± 1%	1.6 ± 14%	5.6	8.3	130

Vegetation

Vegetation samples (usually native grasses) were collected at monthly intervals at the locations shown in figure 2. A portion of each sample was freeze dried and the tritium activity of the recovered water was determined by liquid scintillation counting. The balance of the samples were combined to represent a monthly composite sample. After oven drying this composite sample was analyzed for various gamma-emitting radionuclides with the Ge(Li) detector used for analyzing the airborne particulate samples.

The tritium activities shown in table 13 indicate significant variation from one location to another. As the prevailing wind is from the southwest, one may expect the effect of the laboratory's operation to be minimal at locations 4, 7, 13, 17, and 18. Tritium levels found in vegetation collected from these areas, as well as locations 10 and 11 (onsite), may be exposed to the low level tritium effluent released from the Gaseous Chemistry Building. The samples collected at location 12 represent grass that has been watered by the liquid effluent from the Livermore Sewage Treatment Plant. The whole body radiation doses shown in the table were derived from the model of Anspaugh *et al.* (*5*) assuming that the observed tritium activities were typical of those in edible vegetation grown in this area. The doses are based upon the direct daily consumption of 400 g of vegetation (*4*). This mass of vegetation, however, is assumed to be equivalent to the same mass of water containing the observed tritium concentrations under equilibrium conditions. It is evident that even those samples with elevated tritium concentrations provide rather small whole body radiation doses.

The results of the gamma spectral analyses are shown in table 14. Again, if one makes the assumption that the observed activities are typical of those in edible vegetation, one may calculate the annual whole body or critical organ doses to an adult resulting from the direct ingestion of these radionuclides. These calculated doses, shown in table 14, are based upon adult consumption of 400 g per day of vegetation with a moisture content of 80 percent and the data of Ng, *et al.* (*6*), regarding the dose received per unit of radioactivity consumed under equilibrium conditions. With the exception of global fallout produced cerium-144 and natural potassium-40 activities, these radionuclides deliver appreciably less than 1 mrem/yr to the whole body or critical organ as a result of direct ingestion of edible vegetation. The cerium-144 from global fallout and the naturally occurring potassium-40 activities deliver about 10 and 25 mrem/yr to the lower large intestine and whole body, respectively.

Environmental radiation measurements

Environmental radiation background measurements were made at 12 laboratory perimeter locations shown in figure 2, and at 41 offsite

Table 14. Activities of various radionuclides in Livermore vegetation samples, January-December 1972

Radionuclide	Concentration (pCi/g)						Annual average	Calculated annual dose via direct ingestion (mrem)	Critical organ
	January–June 1972[a]			July–December 1972[a]					
	Maximum	Minimum	Average	Maximum	Minimum	Average			
Cerium-144	7.7 ±26%	0.33 ± 88%	1.8	0.79±43%	0.20 ±100%	0.38	1.1	8.6	Lower large intestine
Cesium-137	.31±46%	.10 ±100%	.28	.68±50%	.10 ±100%	.22	.25	.44	Whole body
Zirconium-95	.29±33%	.010±100%	.083	.21±18%	.010±100%	.10	.090	.22	Lower large intestine
Beryllium-7	3.8 ±34%	1.0 ±100%	2.4	8.5 ±23%	1.1 ± 60%	7.1	4.8	.23	Lower large intestine
Potassium-40	25 ±12%	15 ± 22%	19	22 ±12%	12 ± 26%	17	18	25	Whole body

[a] Data based upon six samples collected monthly.

locations in the vicinity of the laboratory. These measurements were made with CaF_2:Dy (TLD–200) thermoluminescent dosimeters placed at a height of 1 meter above the ground. Exposure periods were usually 3 months. The observed exposure rates reflect the sum of terrestrial and cosmic radiation. Based on past experience, the terrestrial exposure rates in the Livermore Valley vary between 3 and 7 μR/h (26 to 61 mR/yr) depending upon the location; calculated from local elevation and geomagnetic latitudes according to the data of Lowder and Beck (*7*), is approximately 4 μR/h (35 mR/yr). Table 15 shows the quarterly exposure rates obtained at the perimeter locations. Inspection of the data reveals above average exposure rates at location 5, 13, 14, and 15. Location 5 is adjacent to a Cyclotron Building and locations 13, 14, and 15 are near a linear accelerator facility.

Site 300

Atmospheric radioactivity

The concentrations of various particulate airborne radioactive substances were measured continuously at 11 air sampling locations as shown in figures 4 and 5. Ten of the samplers are located within the boundaries of Site 300, and the 11th is located in Tracy, the primary population center of concern. The onsite sam-

Table 15. Environmental radiation background exposure rate measurements at the Livermore Laboratory perimeter, January-December 1972

Location	January-March		April-June		July-September		October-December		Annual (mR/year)
	μR/h	mR/quarter	μR/h	mR/quarter	μR/h	mR/quarter	μR/h	mR/quarter	
1	7.8	17	9.2	20	11	24	12	26	87
2	NS	—	9.7	21	9.0	20	8.8	19	[a] 80
3	11	24	11	24	8.9	19	13	28	95
4	11	24	9.4	20	NS	—	9.5	21	[a] 87
5	12	26	15	33	13	28	16	35	[b] 122
6	9.8	21	11	24	10	22	11	24	91
7	9.2	20	7.9	17	7.9	17	9.2	20	74
8	NS	—	7.5	16	8.8	19	8.3	18	[a] 71
9	7.5	16	8.9	20	8.4	18	7.0	15	69
13	10	22	10	22	9.5	21	13	28	93
14	11	24	11	24	NS	—	12	26	[a] 99
15	12	26	12	26	9.5	21	14	31	104
Average	10	22	10	22	9.6	21	11	24	89

[a] Projected data from 3 quarters.
[b] Neutron dose measurements (using an integration rem meter) near location 5 indicate an annual dose of approximately 250 mrem additional. Neutron doses at the other perimeter locations are normally less than 10 mrem/year.
NS, no sample.

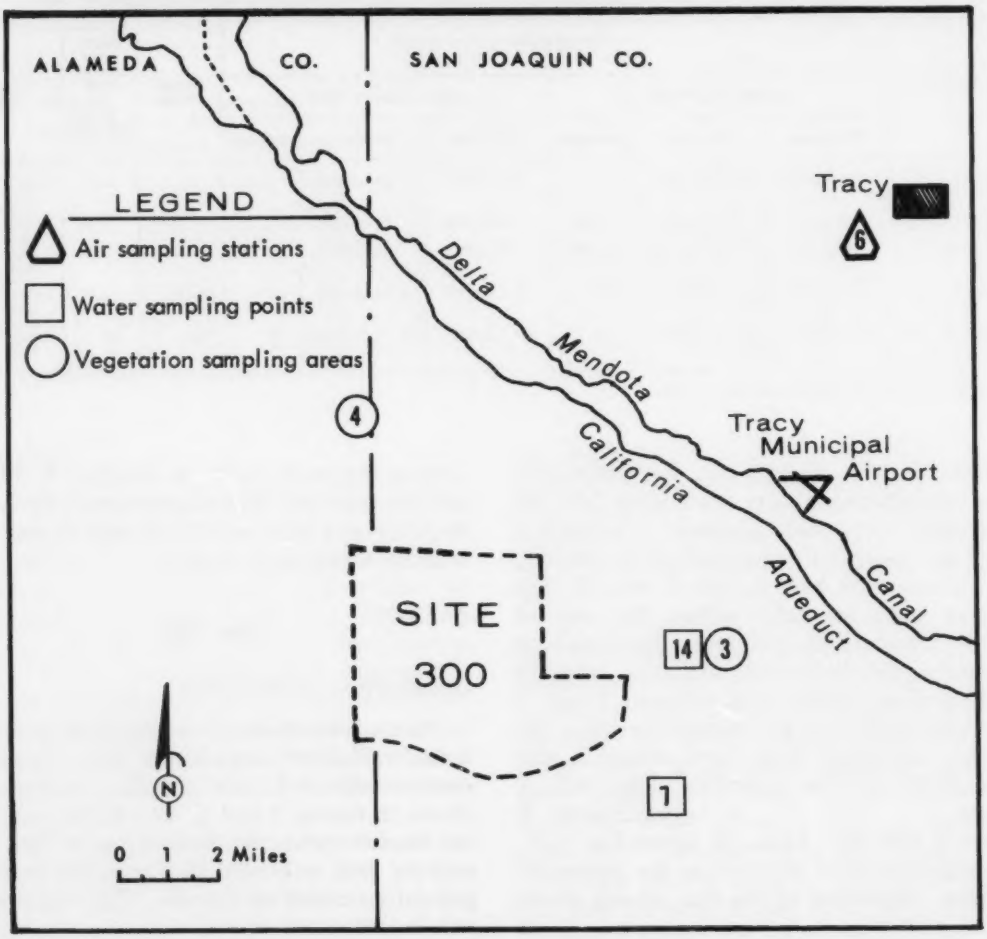

Figure 4. Air, water, and vegetation sampling locations in the Site 300 area (See figure 5 for sampling locations inside Site 300 boundary)

ples were collected on 20- by 25-cm Whatman-41 filters at a flow rate of about 0.7 m^3/min. Samples in Tracy were collected on 10- by 23-cm HV–70 (cellulose-asbestos) filters at a flow rate of about 0.1 m^3/min. Filters were changed twice weekly during the summer months to avoid excessive mass loading and on a weekly basis during the rest of the year. The filters were analyzed by the method previously described for filters used in the Livermore Valley.

No gross alpha radioactivity above the 1 pCi/m^3 detection limit was observed on these filters. The gross beta activities, averaged over 6-month periods, are listed in table 16 for each sampling location. These average radioactivities are slightly higher than those measured in the Livermore Valley, but are within the range of normal variations observed during past years. Gamma spectral measurements made on monthly composite samples of the

Table 16. Airborne particulate beta radioactivity at Site 300, January-December 1972

Sampling location [a]	Activity concentration (pCi/m³)							Annual average	Percent of AEC standard [b]
	Number of samples	January–June 1972			Number of samples	July–December 1972			
		Maximum	Minimum	Average		Maximum	Minimum	Average	
1	30	0.51±1%	0.013 ± 10%	0.14	35	0.25±3%	0.0023±100%	0.068	0.10	10
2	30	.54±1%	.012 ± 11%	.14	33	.20±4%	.0034±100%	.060	.10	10
3	30	.37±2%	.016 ± 7%	.093	35	.20±4%	.013 ± 11%	.055	.074	7
4	30	.64±1%	.014 ± 9%	.12	35	.14±4%	.013 ± 16%	.053	.087	9
5	30	.47±1%	.0075± 9%	.15	35	.20±2%	.013 ± 16%	.056	.10	10
6	21	.14±2%	.0030±100%	.10	19	.45±4%	.011 ± 6%	.037	.069	7
7	29	.50±1%	.016 ± 9%	.15	31	.18±4%	.013 ± 16%	.060	.11	11
8	30	1.1 ±2%	.045 ± 5%	.34	32	.52±3%	.020 ± 21%	.051	.20	20
9	28	.76±1%	.018 ± 8%	.18	35	.20±4%	.0080± 17%	.065	.12	12
10	30	.46±1%	.015 ± 10%	.14	26	.19±7%	.011 ± 16%	.051	.096	10
11	29	.37±1%	.026 ± 4%	.14	33	.23±3%	.010 ± 20%	.055	.098	10

[a] See figures 8 and 9 for sampling locations.
[b] AEC standard is 1 pCi/m³.

filters collected onsite reveal measurable quantities of various gamma-emitting radionuclides as may be seen in table 17. These activity levels are essentially identical with those measured in the Livermore Valley and may readily be accounted for as being due to global fallout. The results of isotopic plutonium and uranium analyses, performed by the techniques described previously, are provided in table 18. The relative abundance of plutonium-238 to plutonium-239 is approximately that expected in global fallout. The uranium content of airborne debris, on the other hand, is appreciably depleted in uranium-235 relative to that of natural uranium and the concentrations are at times significantly greater than those measured in the Livermore Valley. However, these concentrations are nevertheless far lower than the current concentration guide levels.

The calculated annual lung doses to an adult resulting from inhalation of the radionuclides listed in tables 17 and 18 are shown in table 19. These were derived in a manner similar to that used to obtain the values in table 4. Again, these inhalation doses are extremely small with the greatest contribution being due to the cerium-144 from global fallout.

Soil

During 1971, soil samples were collected at 12 sampling locations in the vicinity of the site boundary. Isotopic uranium analyses ob-

Table 17. Results of gamma-ray spectral measurements of Site 300 perimeter air filters, January-December 1972

Month (1972)	Concentration (fCi/m³)							
	Cerium-144	Cerium-141	Antimony-125	Beryllium-7	Ruthenium-103	Ruthenium-106	Cesium-137	Zirconium-95
January	24 ± 6%	47 ± 2%	2.2 ±34%	120±6%	36 ± 4%	1.2 ± 40%	1.9 ±20%	23 ± 8%
February	18 ± 4%	6.9 ± 8%	1.2 ±32%	120±6%	.68±10%	.48± 46%	2.0 ±14%	2.6 ±10%
March	1.3± 4%	.50± 44%	.94±22%	74±4%	.27±76%	.44± 26%	1.6 ±10%	1.0 ±10%
April	27 ±58%	28 ± 2%	2.1 ±20%	170±4%	11 ± 6%	.77± 28%	3.2 ± 8%	32 ± 4%
May	38 ± 2%	38 ± 2%	2.1 ±24%	170±4%	23 ± 4%	1.1 ± 8%	3.9 ± 8%	58 ± 4%
June	39 ± 4%	36 ± 2%	2.2 ±24%	150±4%	33 ± 4%	1.4 ± 22%	4.2 ± 8%	52 ± 4%
July	21 ± 4%	18 ± 2%	1.4 ±29%	120±4%	23 ± 3%	1.0 ± 44%	2.5 ±10%	18 ± 6%
August	18 ± 5%	8.4 ± 7%	1.2 ±40%	170±5%	13 ± 7%	.85± 30%	2.6 ±12%	9.1 ± 5%
September	14 ± 6%	3.7 ± 10%	1.1 ±70%	220±4%	6.2 ±10%	.30± 42%	2.4 ±14%	5.0 ± 7%
October	6.9± 7%	.98± 22%	.56±56%	190±3%	2.1 ±13%	.39± 40%	1.2 ±16%	1.8 ± 9%
November	4.0±10%	.53± 52%	.35±67%	190±4%	1.2 ±25%	.22± 56%	.68±20%	.96±15%
December	2.9±19%	.30±100%	.46±67%	130±4%	.28±57%	.15±100%	.90±22%	.38±25%
Annual average	18	16	1.3	150	13	0.69	2.3	17
AEC standard [a]	200 000	5×10^6	900 000	4×10^7	3×10^6	200 000	500 000	1×10^6
Percent of AEC standard	0.0090	0.00032	0.00015	0.00038	0.00043	0.00035	0.00045	0.0017

[a] Assumes the activity is in an insoluble form.

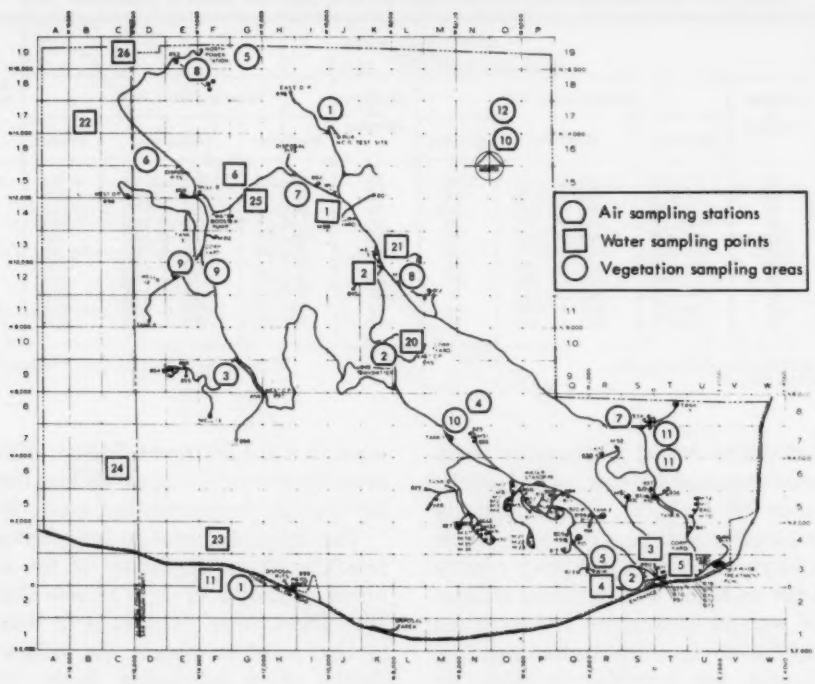

Figure 5. Air, water, and vegetation sampling locations inside Site 300 boundary

Table 18. Plutonium and uranium concentrations in Site 300 air, January-December 1972

Month (1972)	Activity (aCi/m³)		$^{238}Pu/^{239}Pu$	Mass (pg/m³)		$(^{235}U/^{238}U)$[a]
	Plutonium-238	Plutonium-239		Uranium-235[a]	Uranium-238	
January	1.9 ±12%	20 ± 6%	0.095	1.3 ±1%	800 ±6%	0.0017
February	2.3 ± 9%	25 ± 5%	.092	4.6 ±1%	2 300 ±5%	.0020
March	1.9 ± 8%	20 ± 5%	.095	.39 ±2%	130 ±4%	.0030
April	4.8 ± 9%	45 ± 6%	.11	.78 ±2%	170 ±3%	.0046
May	5.7 ±10%	62 ± 6%	.092	.68 ±2%	170 ±4%	.0040
June	5.7 ± 8%	71 ± 6%	.080	.80 ±1%	180 ±3%	.0043
July	2.7 ±28%	48 ±11%	.056	.51 ±1%	100 ±2%	.0051
August	1.5 ±12%	17 ± 6%	.088	(b)	(b)	(b)
September	1.1 ±12%	15 ± 5%	.073	(b)	(b)	(b)
October	.59 ±21%	8.4 ± 8%	.070	.43 ±1%	140 ±2%	.0031
November	1.1 ±11%	12 ± 6%	.092	.81 ±1%	360 ±2%	.0023
December	1.6 ±19%	13 ± 9%	.12	.56 ±1%	260 ±2%	.0022
Annual average	2.4	29		1.1	460	
AEC standard	1×10^{4}	1×10^{4}		1.9×10^{4}	1.5×10^{7}	
Percent of AEC standard	0.00024	0.0029		0.0058	0.0031	

[a] The $^{235}U/^{238}U$ ratio in natural uranium is 0.00725.
[b] No data.
[c] Assumes the activity is in an insoluble form.

Table 19. Inhalation doses resulting from the air concentrations shown in tables 17 and 18

Radionuclide	Calculated annual lung dose (mrem)
Cerium-144	0.30
Cerium-141	.036
Antimony-125	.044
Beryllium-7	.031
Ruthenium-103	.043
Ruthenium-106	.013
Cesium-137	.012
Zirconium-95	.11
Plutonium-238	.0018
Plutonium-239	.020
Uranium-235	.014
Uranium-238	.084

tained by mass spectrometric techniques indicated that the $^{235}U/^{238}U$ ratios in the soil were slightly depleted in uranium-235 which might have resulted from the expenditure of depleted uranium in the high explosive detonations being conducted at the site. Therefore, a major soil sampling program was undertaken during 1972 to determine the extent to which the normal $^{235}U/^{238}U$ ratio in soil samples was perturbed throughout the test site as a result of laboratory operations.

Soil samples were collected at the locations shown in figure 6, using the sampling techniques previously described for collecting soil samples in the Livermore Valley. The results of the isotopic uranium analyses are shown in table 20.

By using the $^{235}U/^{238}U$ ratio in the depleted uranium expended in the high explosive detonations and that in natural uranium, one may calculate the relative amounts of natural and

Table 20. Concentrations of uranium in Site 300 soils, January-December 1972

Sampling location	Depth (cm)	Uranium-234 (pg/g dry weight)	Uranium-235 (ng/g dry weight)	Uranium-236 (pg/g dry weight)	Uranium-238 (μg/g dry weight)	$^{235}U/^{238}U$	Total uranium (μg/g dry weight)	Total natural uranium (μg/g dry weight)	Total depleted uranium (μg/g dry weight)
13	0–5	884 ± 3%	239 ±1%	4 020 ± 2%	124 ± 5%	0.00196	124 ±5%	3.63	120
	5–10	566 ± 4%	152 ±1%	2 530 ± 1%	75.8 ± 5%	.00203	76.0 ±5%	3.18	72.8
	10–15	286 ± 4%	70.0 ±1%	1 060 ± 3%	32.2 ± 5%	.00220	32.3 ±5%	2.36	30.0
	15–20	198 ±16%	40.6 ±2%	510 ±10%	16.7 ± 5%	.00247	16.7 ±5%	2.05	14.6
	20–25	177 ± 6%	37.0 ±2%	409 ± 4%	14.5 ± 3%	.00259	14.5 ±4%	2.10	12.4
14	0–5	317 ±35%	72.8 ±1%	971 ± 2%	31.1 ± 5%	.00237	31.1 ±5%	3.28	27.9
	5–10	180 ± 4%	32.0 ±2%	206 ± 3%	9.33 ± 4%	.00347	9.36 ±4%	2.87	6.49
	10–15	168 ± 6%	26.4 ±2%	106 ± 7%	5.93 ± 4%	.00451	5.96 ±4%	2.97	2.99
	15–20	143 ± 4%	21.8 ±1%	50.9 ± 6%	4.26 ± 3%	.00517	4.28 ±3%	2.66	1.63
	20–25	123 ± 4%	19.2 ±2%	51.3 ± 6%	3.77 ± 3%	.00516	3.79 ±3%	2.34	1.45
15	0–5	151 ± 2%	25.5 ±1%	151 ± 2%	6.88 ± 2%	.00375	6.90 ±2%	2.47	4.43
	5–25	120 ± 2%	17.8 ±1%	41.8 ± 3%	3.33 ± 2%	.00540	3.35 ±2%	2.22	1.13
16	0–5	107 ± 4%	15.9 ±1%	24.4 ± 7%	2.64 ± 2%	.00610	2.65 ±2%	2.10	.56
	5–25	107 ± 2%	15.8 ±1%	27.6 ± 4%	2.76 ± 2%	.00580	2.77 ±2%	2.04	.74
17	0–5	306 ± 3%	82.6 ±1%	1 680 ± 1%	43.2 ± 2%	.00194	43.3 ±2%	1.06	42.2
	5–10	191 ± 5%	47.6 ±1%	660 ± 3%	20.5 ± 3%	.00235	20.6 ±3%	2.06	18.5
	10–15	101 ± 2%	17.4 ±1%	83.2 ± 2%	4.18 ± 2%	.00420	4.20 ±2%	1.85	2.34
	15–20	109 ± 6%	17.7 ±1%	69.5 ± 6%	3.81 ± 2%	.00471	3.83 ±2%	2.05	1.78
	20–25	103 ± 4%	15.9 ±1%	42.6 ± 6%	3.03 ± 2%	.00533	3.04 ±2%	1.98	1.07
18	0–5	170 ± 5%	31.6 ±1%	295 ± 3%	10.8 ± 1%	.00298	10.8 ±1%	2.30	8.50
	5–25	128 ± 3%	18.5 ±1%	18 ±11%	2.94 ± 2%	.00638	2.96 ±2%	2.50	.47
19	0–5	322 ± 2%	76.7 ±1%	1 040 ± 1%	36.2 ± 1%	.00214	36.3 ±1%	2.30	34.0
	5–25	149 ± 2%	33.3 ±1%	397 ± 1%	14.1 ± 2%	.00239	14.2 ±2%	1.50	12.6
20	0–5	89 ± 8%	11.7 ±2%	7.5 ±24%	1.70 ± 3%	.00694	1.71 ±3%	1.62	.10
	5–25	98 ±10%	12.5 ±2%	7.2 ±36%	1.77 ± 3%	.00714	1.75 ±3%	1.74	.04
21	0–5	108 ± 7%	13.9 ±1%	8.9 ±22%	2.06 ± 3%	.00683	2.07 ±3%	1.91	.16
	5–25	99 ± 7%	12.7 ±2%	6.1 ±22%	1.78 ± 5%	.00721	1.80 ±4%	1.78	.02
22	0–5	88 ± 7%	11.8 ±2%	7.4 ±22%	1.74 ± 3%	.00686	1.78 ±3%	1.62	.12
	5–25	94 ± 6%	12.4 ±2%	3.6 ±33%	1.73 ± 3%	.00726	1.74 ±3%	1.74	.0
23	0–5	1 380 ± 3%	335 ±1%	4 110 ± 2%	147 ± 5%	.00230	148 ±5%	13.5	134
	5–25	86 ± 5%	13.1 ±2%	13 ±15%	2.07 ± 3%	.00644	2.08 ±3%	1.77	.31
24	0–5	97 ± 4%	14.9 ±1%	25 ± 8%	2.51 ± 3%	.00602	2.52 ±3%	1.96	.57
	5–25	95 ± 4%	14.4 ±1%	5.0 ±20%	2.05 ± 3%	.00708	2.07 ±3%	2.00	.06
25	0–5	82 ± 4%	1.37 ±8%	51 ± 4%	2.95 ± 2%	.00470	2.97 ±2%	1.58	1.39
	5–10	62 ± 5%	9.82 ±1%	17 ± 6%	1.69 ± 2%	.00588	1.70 ±2%	1.27	.43
	10–15	75 ± 3%	11.6 ±1%	16 ± 6%	1.93 ± 2%	.00608	1.94 ±2%	1.52	.42
	15–20	56 ± 5%	9.08 ±1%	14 ± 7%	1.53 ± 1%	.00600	1.54 ±1%	1.19	.35
26	0–5	117 ± 3%	22.4 ±2%	194 ± 3%	7.53 ± 4%	.00302	7.55 ±4%	1.69	5.86
	5–25	79 ± 5%	12.1 ±2%	13 ±15%	1.93 ± 3%	.00637	1.94 ±3%	1.61	.31
27	0–2	93 ± 4%	13.9 ±1%	12 ±15%	2.20 ± 3%	.00639	2.22 ±3%	1.87	.35
	2–25	96 ± 4%	14.5 ±1%	7.0 ±14%	2.09 ± 3%	.00703	2.10 ±3%	2.02	.08
28	0–2	77 ± 5%	11.0 ±2%	10 ±20%	1.70 ± 4%	.00651	1.71 ±4%	1.48	.23
	2–25	83 ± 5%	11.7 ±2%	5.8 ±20%	1.68 ± 2%	.00704	1.69 ±2%	1.62	.07
29	0–2	89 ± 5%	12.4 ±2%	11 ±18%	1.90 ± 3%	.00659	1.91 ±3%	1.68	.23
	2–25	95 ± 4%	12.9 ±2%	5.0 ±20%	1.82 ± 3%	.00719	1.83 ±3%	1.81	.02
30	0–25	103 ± 3%	17.1 ±1%	86 ± 2%	4.47 ± 2%	.00387	4.48 ±2%	1.70	2.78
31	0–25	101 ± 3%	18.2 ±1%	103 ± 3%	5.21 ± 2%	.00354	5.23 ±2%	1.67	3.56
32	0–25	120 ± 3%	17.4 ±1%	11 ± 9%	2.60 ± 2%	.00678	2.62 ±2%	2.39	.22
33	0–25	87 ± 2%	13.4 ±1%	10 ±10%	2.01 ± 1%	.00678	2.02 ±2%	1.84	.17
34	0–25	94 ± 3%	13.8 ±1%	11 ± 9%	2.02 ± 1%	.00689	2.04 ±2%	1.90	.13
35	0–25	102 ± 3%	17.0 ±1%	85 ± 1%	4.32 ± 2%	.00398	4.34 ±2%	1.74	2.60
36	0–25	133 ± 2%	20.0 ±1%	21 ± 5%	3.09 ± 2%	.00654	3.11 ±2%	2.71	.41
37	0–25	90 ± 3%	12.8 ±1%	15 ± 7%	2.11 ± 2%	.00617	2.12 ±2%	1.70	.42

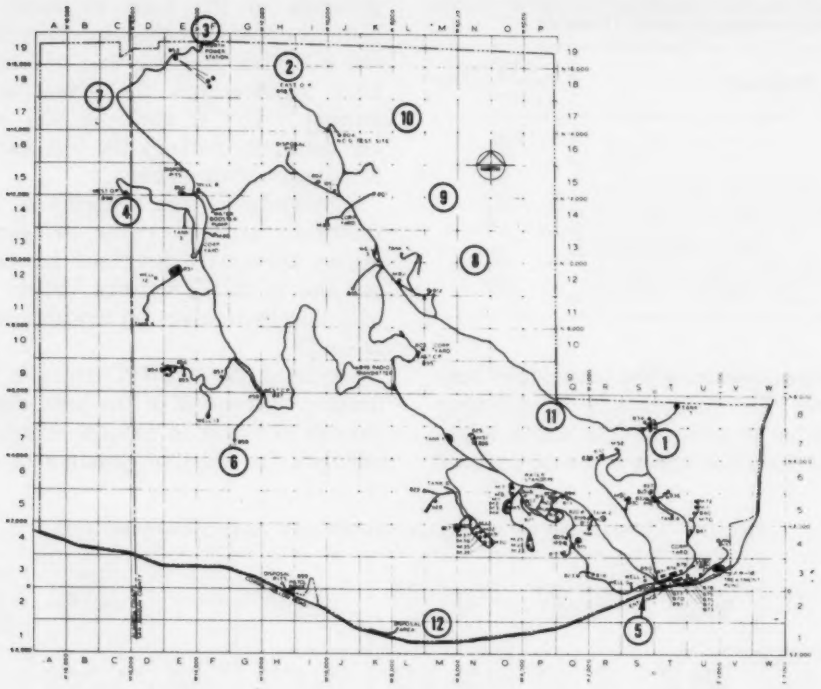

Figure 6. Site 300 soil sampling locations

depleted uranium in the samples. These data are also included in table 20. Inspection of the data indicates that detectable amounts of depleted uranium may be found in samples collected as much as 500 m from the firing bunkers. Depth profile studies at locations 13, 14, and 17 show that the depleted uranium may be found to the maximum depth sampled probably as a result of natural erosion and/or mechanical mixing processes. Samples collected more than roughly 500 m away from the firing bunkers show essentially no detectable amounts of depleted uranium. While it is clear that the laboratory's operations have produced a detectable increase in uranium near the firing bunkers, the affected areas are well within the site boundaries.

Some of the samples were also subjected to plutonium analysis by standard radiochemical techniques. The results of the analyses are shown in table 21. A review of the data indicates the activity levels are similar to those measured within the Livermore Valley and

Table 21. Plutonium activities in Site 300 soils, January-December 1972

Sampling location	Activity			Deposition
	Depth (cm)	Plutonium-238 (aCi/g)	Plutonium-239 (fCi/g)	Plutonium-239 (nCi/m²)
13	0–25		2.3± 9%	0.87
14	0–25		2.8± 9%	1.0
15	0–25	64 ±38%	2.1± 8%	.75
16	0–25	41 ±45%	1.3± 9%	.51
17	0–25	100 ±44%	2.8±10%	1.0
18	0–25	140 ±28%	3.5± 7%	1.4
19	0–25	140 ±32%	1.7±10%	.75
20	0–25	9.0±41%	2.1±12%	.74
21	0–25	55 ±41%	2.6±10%	1.0
22	0–25	55 ±39%	1.9±12%	.73
23	0–25	20 ±24%	5.5± 6%	2.2
24	0–25	150 ±22%	3.0± 6%	1.1
25	0– 5	320 ±25%	6.0± 8%	
	5–10	110 ±28%	3.0± 7%	
	10–15	90 ±40%	1.9±10%	
	15–20	45 ±44%	1.3± 9%	
	20–25	190 ±23%	1.7±10%	
26	0–25	150 ±32%	3.0± 8%	1.1
27	0–25	120 ±29%	2.6± 7%	.96
28	0–25	160 ±24%	2.1± 8%	.76
29	0–25	310 ±20%	3.1± 8%	1.2
30	0–25	250 ±22%	1.6±10%	.60
31	0–25	220 ±27%	3.4± 8%	1.3
32	0–25	140 ±34%	2.1±10%	.82
33	0–25	80 ±40%	2.5± 9%	.93
34	0–25	120 ±34%	2.0±10%	.74
35	0–25	110 ±38%	2.5± 9%	.94
36	0–25	160 ±29%	2.4± 9%	.88
37	0–25	180 ±30%	2.2±10%	.83
	0–25	110 ±36%	2.0±10%	.74

may readily be accounted for as being due to global fallout.

Water

Samples were collected from onsite wells supplying Site 300 and from various onsite and offsite springs, ponds, and creeks. The locations of these sites are shown in figures 4 and 5. Locations 1 through 7 represent deep-well sources, locations 11 and 14 are offsite creek sources, and rain water is collected at location 20. The remaining locations are onsite ponds or springs. The samples were subjected to gross alpha and beta analyses. No samples showed a gross alpha activity above the limit of detection of 1.2 pCi/liter. The gross beta activities averaged over 6-month periods are given in table 22. These activities show little variation with time and location and are similar to those exhibited by the water samples collected within the Livermore Valley.

These samples were also subjected to tritium analyses by electrolytic enrichment and subsequent scintillation counting. The results of the analyses are shown in table 23. With the exception of samples collected at location 25, these samples contain tritium activities that are comparable with those observed in water samples collected within the Livermore Valley. Water in the spring at location 25 does not appear to migrate, as a nearby deep-water well

Table 22. Gross beta activities in Site 300 water samples, January-December 1972

Sample location	Number of samples	Concentration (pCi/liter)							Annual average	Percent AEC standard[a]
		January-June 1972			Number of samples	July-December 1972				
		Maximum	Minimum	Average		Maximum	Minimum	Average		
1	5	2.8±56%	1.8± 53%	2.2	5	12 ±17%	2.0± 60%	5.0	3.6	12
2	5	5.8±26%	3.7± 42%	4.3	5	11 ±17%	4.4± 32%	5.8	5.1	17
3	5	7.6±21%	2.2± 57%	5.6	5	13 ±16%	3.6± 41%	6.5	6.1	20
4	2	5.4±29%	2.9± 42%	4.1	2	3.4±37%	2.6± 54%	3.0	3.6	12
5	5	6.0±25%	3.4± 38%	5.0	5	12 ±16%	4.0± 38%	5.9	5.5	18
6	5	5.5±31%	2.1± 53%	4.2	5	11 ±18%	3.4± 38%	5.3	4.8	16
7	5	6.1±30%	4.3± 31%	5.3	5	11 ±17%	4.6± 34%	6.4	5.9	20
11	4	9.8±18%	4.2± 38%	6.3	5	14 ±15%	7.2± 23%	9.4	7.9	26
14	3	5.5±27%	2.8± 43%	4.1	1			5.6	4.9	16
20	1			3.8	2	11 ±17%	1.7±100%	6.5	5.2	17
21	4	16 ±30%	2.6± 60%	7.1	4	15 ±14%	7.3± 23%	10	8.6	29
23	4	7.3±22%	6.4± 27%	7.0	4	13 ±15%	5.8± 26%	8.2	7.6	25
24	4	8.0±21%	5.5± 28%	6.3	4	13 ±16%	6.7± 23%	8.4	7.4	25
25	5	3.6±38%	1.6±100%	2.5	4	9.4±19%	3.9± 34%	5.2	3.9	13
26	4	6.0±29%	2.3± 67%	4.7	4	11 ±18%	5.8± 26%	7.0	5.9	20

[a] AEC standard (beta activity) = 30 pCi/liter.

Table 23. Tritium activities in Site 300 water samples, January-December 1972

Sample location	Number of samples	Concentration (pCi/liter)							Annual average	Percent AEC standard[a]	Calculated annual adult whole body dose (μrem)
		January-June 1972			Number of samples	July-December 1972					
		Maximum	Minimum	Average		Maximum	Minimum	Average			
1	2	17± 88%	11 ±100%	14	4	320±43%	8.0±100%	90	52	.0017	2.1
2	2	17± 94%	11 ±100%	14	3	45±27%	8.0±100%	32	23	.00077	.92
3	3	14± 95%	4.9±100%	8.0	3	59±27%	12 ±100%	30	19	.00063	.76
5	3	31± 40%	24 ± 57%	26	3	43±28%	22 ± 60%	31	28	.00093	1.1
6	2	14± 80%	3.0±100%	8.5	3	29±41%	9.0±100%	17	13	.00043	.52
7	3	11±100%	11 ±100%	11	3	20±60%	17 ±100%	19	15	.00050	.60
11	3	430± 4%	5.0±100%	170	2	16±75%	9.0±100%	12	90	.0030	3.6
20	2	95± 15%	94 ± 14%	95	0				95	.0032	3.8
21	2	30± 69%	19 ± 37%	25	3	190± 9%	36 ± 42%	93	59	.0020	2.4
23	3	200± 8%	14 ±100%	77	3	20±55%	8.0±100%	15	46	.0015	1.8
24	2	23± 57%	5.0±100%	14	3	20±55%	11 ±100%	16	15	.00050	.60
25	4	810 000± 2%	670 000 ± 2%	770 000	4	1 000 000± 2%	710 000 ± 2%	830 000	800 000	27	32 000
26	2	28± 50%	11 ±100%	19	3	16±69%	10 ±100%	12	16	.00053	.64

[a] AEC standard (HTO) = 3 μCi/liter.

at location 6 exhibits normal background tritium levels.

Table 23 also includes the calculated whole body doses to an adult consuming the water containing the listed tritium concentrations. These doses were derived in a manner similar to that used to compute the values listed in table 9. As one would expect, the doses are insignificant with the exception of the spring at location 25. However, the water from this spring percolates back into the ground a few feet from the spring, and is not used in laboratory operations or for drinking.

Vegetation

Vegetation samples were collected on a monthly basis with the exception of May and December at 12 sampling locations shown in figure 5. Dried monthly composite samples were subjected to gamma spectral analyses yielding the activities of cesium-137, cerium-144, beryllium-7, and potassium-40. The results of the analyses are shown in table 24. Also shown in the table are the calculated whole body or critical organ doses delivered to an adult by direct ingestation of 400 grams per day of edible vegetation containing 80 percent water and the listed average activities. Again, the data reveal that potassium-40 and cerium-144 are the major contributors via this pathway.

These samples were also subjected to tritium analyses by freeze-drying and scintillation counting of the resulting water. The results are shown in table 25. The activities show little fluctuation compared with the results obtained from similar samples collected within the Livermore Valley. The table also includes the resulting whole body doses delivered to an adult by the tritium activities based upon the models referenced previously. As one would expect these doses are insignificant.

Table 24. Activities of various radionuclides in Site 300 vegetation samples, January-December 1972

Radionuclide	Concentration (pCi/g)						Annual average	Calculated annual dose via direct ingestion (mrem)	Critical organ
	January-June 1972[a]			July-December 1972[a]					
	Maximum	Minimum	Average	Maximum	Minimum	Average			
Cerium-144	2.0 ±20%	0.35 ±100%	0.84	0.92 ±41%	0.34 ±100%	0.56	0.70	5.5	Lower large intestine
Cesium-137	.18 ±74%	.080 ±100%	.13	.15 ±82%	.043 ±100%	.14	.14	.25	Whole body
Beryllium-7	3.8 ±34%	1.9 ± 48%	2.6	6.7 ±34%	1.5 ± 50%	3.3	3.0	.15	Lower large intestine
Potassium-40	31 ±20%	16 ± 30%	22	26 ±29%	13 ± 28%	19	21	29	Whole body

[a] Based on 5 samples.

Table 25. Tritium activities in Site 300 vegetation samples, January-December 1972

Sample location	Concentration (pCi/liter)								Calculated annual adult whole body dose (μrem)
	Number of samples	January–June 1972			Number of samples	July–December 1972			Annual average
		Maximum	Minimum	Average		Maximum	Minimum	Average	
1	3	160 ±100%	18 ±100%	100	4	260 ±80%	18 ±100%	180	140	2
2	4	10 000 ± 3%	18 ±100%	3 600	4	150 ±90%	18 ±100%	130	1 800	30
3	5	410 ± 40%	18 ±100%	240	4	280 ±54%	18 ±100%	250	240	4
4	3	550 ± 50%	18 ±100%	390	4	390 ±39%	18 ±100%	250	320	5
5	4	450 ± 35%	18 ±100%	290	3	420 ±36%	220 ± 74%	330	310	5
6	4	8 100 ± 3%	18 ±100%	4 500	2	92 000 ± 1%	2 100 ± 8%	47 000	26 000	400
7	5	680 ± 23%	18 ±100%	230	4	360 ±42%	18 ±100%	300	260	4
8	3	770 ± 21%	18 ±100%	320	4	1 100 ±15%	18 ±100%	410	370	6
9	5	600 ± 37%	18 ±100%	400	4	2 300 ± 9%	640 ± 34%	920	660	10
10	5	550 ± 48%	18 ±100%	200	4	270 ±62%	18 ±100%	160	180	3
11	5	400 ± 65%	18 ±100%	190	3	420 ±50%	18 ±100%	220	200	3
12	4	310 ± 53%	18 ±100%	250	3	460 ±45%	18 ±100%	280	260	4

Table 26. Radionuclide activity observed in milk samples, January-December 1972

Radionuclide	Number of samples	Concentration (pCi/liter)			Calculated annual adult radiation dose (mrem)	Critical organ
		Maximum	Minimum	Average		
Cesium-137	6	5.2	1.8	2.7	0.016	Whole body
Cerium-144	7	87	13	33	.84	Lower large intestine
Tritium	8	290	110	170	.00052	Whole body
Potassium-40	3	1 400	1 300	1 400	6.3	Whole body

Milk

The only dairy in the general vicinity of laboratory operations is located about 10 km southwest of Tracy. Periodic milk samples were collected from the dairy throughout the year. Before analysis, the samples were concentrated by means of freeze drying, which normally yields about 2 liters of concentrate from 9 liters of fresh milk. The concentrates were subjected to gamma spectral analysis by counting them between two 20 by 10 cm NaI(Tl) crystals. In addition, each sample was analyzed for tritium activity by counting 1 ml of the water recovered from freeze drying in a liquid scintillation counting system. Activities of cesium-137, cerium-144, potassium-40, and tritium are shown in table 26. Also shown are the calculated annual adult whole body or critical organ radiation dose delivered to man via the milk pathway. These calculations are based on a daily intake of 260 g/day (*4*) and the models previously referenced. As expected, the only significant dose to an individual is that from naturally occurring potasium-40.

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Previous coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1971	October 1973

2. National Reactor Testing Station[3] January-December 1972

Health Services Laboratory
U.S. Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) was established in 1949 by the U.S. Atomic Energy Commission (AEC) to promote reactor development by building, testing, and operating various types of nuclear reactors, allied plants, and equipment. By 1972, 50 reactors had been built at the NRTS and 16 were still operating or operable.

The NRTS is situated on the Upper Snake River Plain in southeastern Idaho at an average elevation of 1500 meters. The station is comprised of 16 200 km^2 of sagebrush and basalt fields and the boundary stretches 63 km northwest of Blackfoot, 80 km northwest of Pocatello, and 11 km southeast of Arco, Idaho (figure 7).

[3] Summarized from Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, "National Reactor Testing Station, 1972."

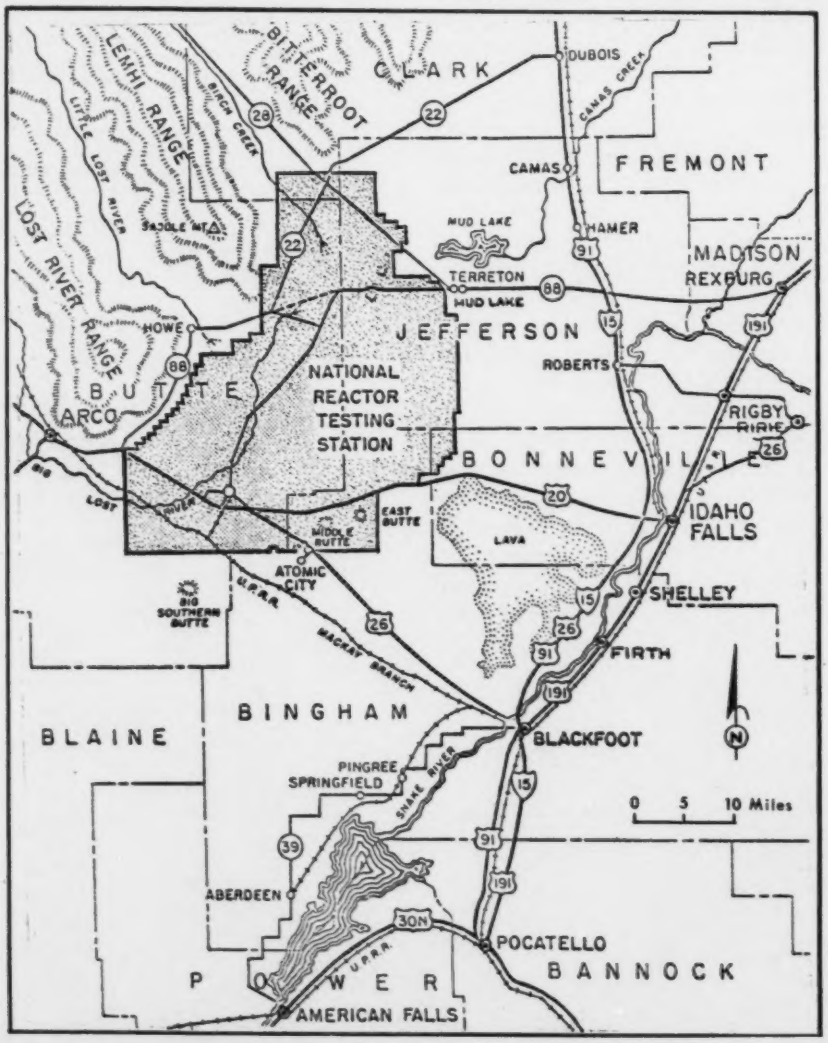

Figure 7. National Reactor Testing Station environs

Although annual precipitation in the NRTS area has averaged only 22 cm, underlying the desert plain is a huge natural underground reservoir of water in the basaltic lava rock. The lateral flow of this water is about 4 billion liters per day. Aquifer water is supplied principally from Henry's Fork of the Snake River. Additional water comes from the Big and Little Lost Rivers and Birch Creek, which start in the mountains to the north and sink into the porous soils of the NRTS area. The underground water seeps slowly at a rate of 1.5 to 6 meters per day to the south and west, emerging in numerous springs along the Snake River between Milner and Bliss, Idaho. Both aquifer and surface waters of the Snake River are used for irrigation of crops.

Major programs currently underway at the NRTS fall into five major categories. One program provides test irradiation services from the two operating high-flux test reactors, the ETR and ATR. The Idaho Chemical Processing Plant (ICPP) recovers uranium from highly enriched spent fuels. A third major program is that of light-water-cooled reactor safety testing and research. The Loss-of-Fluid Test (LOFT) and the Power Burst Facility (PBF) are the major projects in the reactor safety program. Other significant programs include the operation of the Experimental Breeder Reactor II (EBR–II) by Argonne National Laboratory and the operation of the Naval Reactor Facility (NRF).

Because of these small activities, small amounts of radioactivity were released to the atmosphere and the Snake River Plain aquifer. In its environmental monitoring program, the Health Services Laboratory (HSL) of the AEC measured the levels of radioactivity in air, groundwater, surface water, milk, and wheat samples. Gamma radiation exposures in air were also measured.

Air monitoring

Air samplers were operated continuously and drew air through sets of filters for weekly periods. A membrane prefilter (Gelman Model AN–800) for collection of particulates was followed by an inline activated charcoal-impregnated cellulose fiber filter (Gelman Model AS–1) for removal of radioiodine from the air stream. An average air flow of approximately 0.03 cubic meters per minute was maintained. Air samplers were located onsite, in the small communities close to the NRTS boundary, and at distant background sites (figure 8). The locations provide comprehensive surveillance of atmospheric radioactivity and theoretically made it possible to differentiate worldwide fallout from NRTS releases. The air sampling network was expanded during 1972 by adding samplers at two additional boundary communities (Monteview, Reno Ranch) and one onsite (EFS) location.

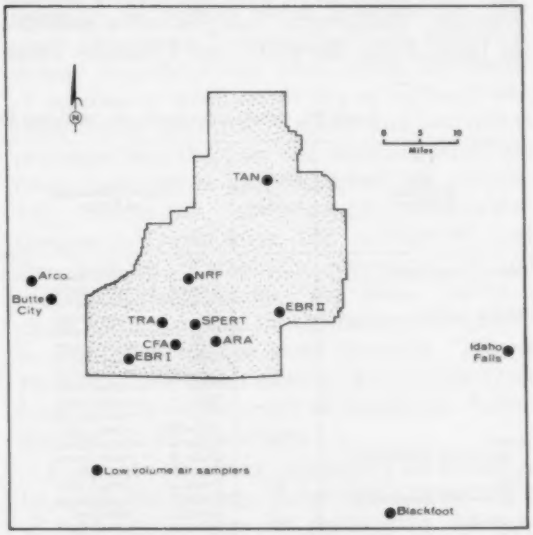

Figure 8. Onsite and offsite air sampling locations National Reactor Testing Station

The filters were analyzed 5 days after the end of each sampling period to allow for decay of short-lived natural radioactivity. Gross alpha and beta analyses were performed on the membrane filters, and gross beta analyses alone were performed on the charcoal filters. Activity detected on the charcoal filters was assumed to be iodine-131. Gross alpha activity was determined by a technique reported by Hallden and Harley (7). Using this method, an alpha-sensitive phosphor disc was placed in direct contact with the filter and counted with a low-noise photomultiplier tube. For gross

beta analyses, the filters were mounted on a ringed phanchet and counted in a low background beta counter. At the end of each calender quarter, the particulate filters from selected locations were composited and the concentrations of gamma-emitting radionuclides determined by gamma spectrometry. A strontium-90 analysis was also performed on the quarterly composites. Each membrane filter was dried and weighed before and after use to determine the average airborne particulate concentration during the sampling period.

Onsite air samples were collected at locations close to the sources of released radioactivity and were expected to have the highest concentrations. Background samples were collected at Idaho Falls, Blackfoot, and Pocatello. These locations were sufficiently remote to ensure that any radioactivity detected was due to natural background or sources other than NRTS operations. Levels of radioactivity in onsite and boundary community (Arco, Monteview, Reno Ranch, Butte City, Howe, and Mud Lake) air samples were compared to levels in the background samples. If the radioactivity levels were found to be significantly higher than background, the net amount above background was assumed to be radioactivity introduced to the environment from NRTS operations. The net concentrations of radioactivity were then compared to the AEC standards set forth in the U.S. Atomic Energy Commission's Manual Chapter 0524 (AECM). The air sampling data are presented in table 27.

Table 27. Radioactivity in air, National Reactor Testing Station, January-December 1972

Sampling locations	Number of samples	Type of analysis and filter	Minimum detectable concentration (fCi/m³)	Maximum single concentration (fCi/m³)	Average sample concentration (fCi/m³)	Average background concentration (fCi/m³)	Maximum average net concentration (fCi/m³)	AEC standard (fCi/m³) [a]
Onsite (9 locations)	428	Gross α —membrane	1	4.0	1.6	(a)	1.6	6 000
		Gross β —membrane	10	4 600	290	280	10	[b] 30 000
		Gross β —charcoal	10	59	<20	<20	<20	9×10^{4}
EBR–1 (onsite)	52	^{90}Sr —membrane	(d)	• 9.3	5.7	2.0	3.7	1×10^{4}
		^{95}Zr —membrane	(d)	• 26	<11	<12	<11	3×10^{7}
		^{95}Nb —membrane	(d)	• 45	<16	<17	<16	1×10^{5}
		^{103}Ru —membrane	(d)	• 13	<5.4	6.5	<5.4	8×10^{7}
		^{106}Ru-Rh —membrane	(d)	• 25	(c)			6×10^{4}
		^{125}Sb —membrane	(d)	• 5.2	(c)			3×10^{7}
		^{137}Cs —membrane	(d)	• 11	<7.1	<3.5	<7.1	1×10^{7}
		^{141}Ce —membrane	(d)	• 18	<6.9	<5.7	<6.9	2×10^{5}
		^{144}Ce-Pr —membrane	(d)	• 43	<22	<16	<22	6×10^{4}
Arco (Boundary community)	52	Gross α —membrane	1	3.8	1.7	(a)	1.7	20
		Gross β —membrane	10	1 500	300	280	20	[b] 1 000
		Gross β —charcoal	10	750	<30	<20	<30	1×10^{5}
Howe (Boundary community)	52	Gross α —membrane	1	3.6	1.6	(a)	1.6	20
		Gross β —membrane	10	1 500	260	280	None	[b] 1 000
		Gross β —charcoal	10	420	<20	<20	<20	1×10^{5}
Monteview (Boundary community)	52	Gross α —membrane	1	4.3	1.6	(a)	1.6	20
		Gross β —membrane	10	3 100	250	280	None	[b] 1 000
		Gross β —charcoal	10	250	<20	<20	<20	1×10^{5}
Reno Ranch (Boundary community)	52	Gross α —membrane	1	3.2	1.5	(a)	1.5	20
		Gross β —membrane	10	1 700	250	280	None	[b] 1 000
		Gross β —charcoal	10	140	<10	<20	<10	1×10^{5}
Butte City (Boundary community)	52	Gross α —membrane	1	2.9	1.5	(a)	1.5	20
		Gross β —membrane	10	2 000	260	280	None	[b] 1 000
		Gross β —charcoal	10	600	<30	<20	<30	1×10^{5}
		^{90}Sr —membrane	(d)	• 3.8	2.7	2.0	.7	30 000
		^{95}Zr —membrane	(d)	• 22	<9.3	<12	<9.3	1×10^{4}
		^{95}Nb —membrane	(d)	• 25	<12	<17	<12	3×10^{4}
		^{103}Ru —membrane	(d)	• 12	(c)			3×10^{4}
		^{125}Sb —membrane	(d)	• 11	(c)			9×10^{4}
		^{137}Cs —membrane	(d)	• 14	<5.7	<3.5	<.57	5×10^{4}
		^{141}Ce —membrane	(d)	• 14	(c)			5×10^{4}
		^{144}Ce-Pr —membrane	(d)	• 39	(c)			2×10^{5}
Mudd Lake (Boundary community)	52	Gross α —membrane	1	4.4	1.8	(a)	1.8	20
		Gross β —membrane	10	1 500	250	280	None	[b] 1 000
		Gross β —charcoal	10	160	<10	<20	<10	1×10^{5}
		^{90}Sr —membrane	(d)	• 3.7	1.9	2.0	None	30 000
		^{95}Zr —membrane	(d)	• 26	<10	<12	<10	1×10^{4}
		^{95}Nb —membrane	(d)	• 33	<12	<17	<12	3×10^{4}
		^{103}Ru —membrane	(d)	• 14	5.6	<6.5	<5.6	3×10^{4}
		^{106}Ru-Rh —membrane	(d)	• 24	(c)			2×10^{5}
		^{137}Cs —membrane	(d)	• 5.0	(c)			5×10^{4}
		^{141}Ce —membrane	(d)	• 14	(c)			5×10^{4}
		^{144}Ce-Pr —membrane	(d)	• 39	<20	<16	<20	2×10^{4}

[a] Background gross alpha concentrations representative of the NRTS were not available.
[b] Assumes actinium-227 not present.
[c] The maximum quarterly average.
[d] Detection limits varied because of different air flow volumes and counting times for these quarterly composite samples.
[e] A meaningful average could not be computed; the radionuclide was detected in only one of two quarterly composite samples.

The gross alpha air concentrations at the background locations of Idaho Falls, Blackfoot, and Pocatello were not representative of the NRTS background levels. This was due to higher airborne concentrations of naturally occurring radioactivity in the upper Snake River Valley. Therefore, the onsite and NRTS boundary community gross alpha concentrations are not compared to an average background concentration. In determining the maximum net average concentration of gross alpha activity presented in table 27, the background was assumed to be zero. However, if measurable onsite releases of alpha activity were occurring, it would have been expected that the gross alpha concentrations at onsite locations would be higher than at the communities near the NRTS boundary. This pattern was not observed and indicates the gross alpha concentrations measured at the NRTS and boundary community locations were the result of natural background radioactivity.

During 1972, two foreign atmospheric tests of nuclear devices took place. One test occurred January 7, 1972, and the other on March 18, 1972. Increased levels of airborne radioactivity were observed at all sampling locations following these tests. Because of the local nature of some of the natural aerosol clearing processes (such as scattered showers), the amount of increase in radioactivity at each location varied. During these periods, the establishment of a known background air concentration was impossible and valid comparisons between onsite, boundary community, and background air concentrations of radioactivity could not be made.

Except when fresh worldwide fallout was present, all the gross beta (iodine-131) concentrations determined from the charcoal filters were near or below the detection limit of the analysis. The highest gross beta (iodine-131) concentration found on a charcoal filter was 0.75 pCi/m^3 and this occurred at Arco, Idaho following the January 7, 1972 foreign atmospheric test. Even this maximum concentration was well below the standard of 100 pCi/m^3.

For 1972, the average gross beta (long life only) concentration of particulate material at onsite locations was 0.29 pCi/m^3. The highest individual average was 0.36 pCi/m^3, occurring at the TRA sampling location. These concentrations are lower than the average and maximum which occurred last year (1971) of 0.65 pCi/m^3 and 0.82 pCi/m^3, respectively. All onsite concentrations in air were well below the standard of 30 pCi/m^3.

The 1972 averages would have been even lower if the foreign atmospheric tests had not been conducted. The yearly average concentration of background gross beta activity was 0.28 pCi/m^3. Although the overall onsite average of gross beta activity in air was only slightly above the background level, a few onsite locations did have concentrations as much as 26 percent above background. The small differences between the onsite and background concentrations were likely the result of releases of small quantities of radioactivity from onsite facilities. Fission and activation products identified on the onsite particulate filters were cerium-praseodymium-144, cerium-141, cesium-137, antimony-125, ruthenium-rhodium-106, ruthenium-103, niobium-95, and strontium-90. Except for antimony-125 and ruthenium-rhodium-106, the same radionuclides were identified on the background filters in approximately the same amounts. This is further evidence that most of the long life gross beta activity is the result of worldwide fallout and not NRTS operations.

At the six boundary community air sampling locations, the average gross beta concentration of 0.26 pCi/m^3 was not statistically different from the background concentration of 0.28 pCi/m^3. These levels too would have been lower if not for the fallout from foreign nuclear device testing in the atmosphere. Only the radionuclides identified on the background filters were also identified on the boundary community filter. Thus, there is no evidence which suggests an increase in the concentrations of radioactivity in air at the boundary community locations.

The monthly average onsite and background location gross beta air concentrations (long life only) for 1970, 1971, and 1972 are plotted in figure 9. The monthly average boundary community gross beta concentrations are also plotted for 1971 and 1972. These air concen-

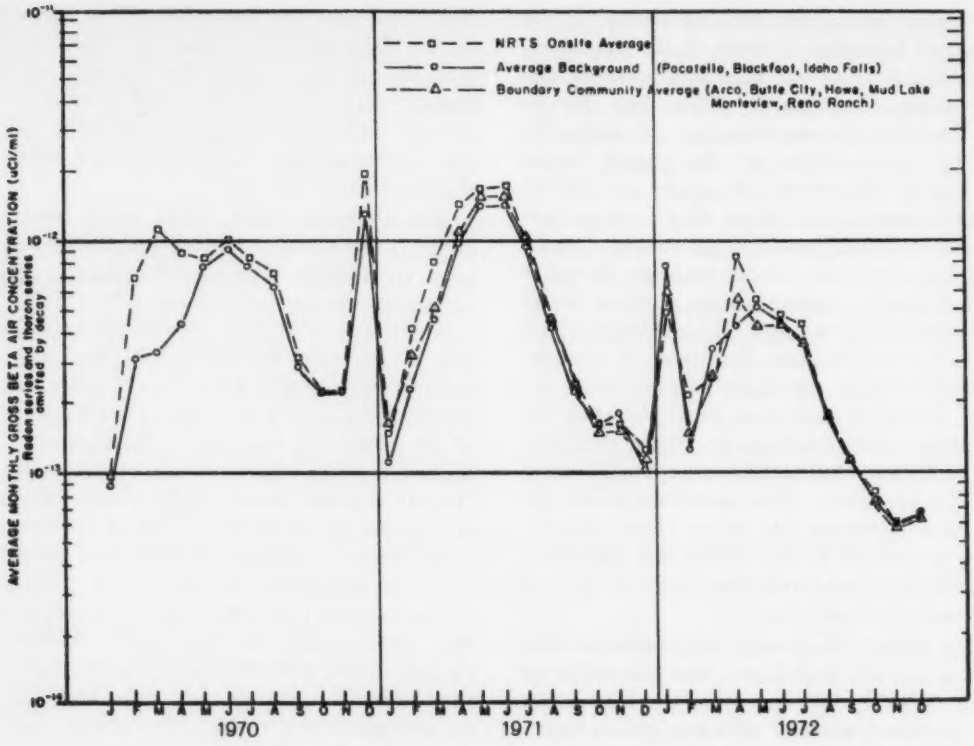

Figure 9. Variation in worldwide fallout plus NRTS released gross beta concentrations with time of year

trations are mainly due to worldwide fallout activity from nuclear tests. Increases in the onsite average above world fallout levels such as occurred early in 1970, the first half of 1971, and the middle of 1972 are likely the result of atmospheric releases from the NRTS. Sharp increases in both onsite and offsite concentrations as measured late in 1970 and early in 1972 were the result of fresh radioactive fallout from the testing of nuclear devices at sites other than the NRTS. The scatter between the background average and the boundary community average during the first half of 1972 is a result of the local variation in the levels of fresh fallout from the foreign atmospheric testing. The rise in background during the spring and summer months of each year is due to the increased transport of stratospheric air and its accompanying radioactivity during those seasons.

Water monitoring

Water samples were collected from onsite and offsite drinking water production wells and from the Snake River. Onsite and offsite water sampling locations can be seen in figures 10 and 11, respectively. All offsite samples were collected semiannually; onsite samples were generally collected every 2 weeks. Gross alpha, gross beta, and tritium analyses were routinely performed on the water samples. For gross alpha analysis, an aliquot of the sample was evaporated on a stainless steel planchet and counted with a scintillation counter using a technique similar to that described for the gross alpha analysis for the air filters. Another aliquot was evaporated and counted for gross beta activity in a low background beta counter. Tritium concentrations were determined with a Beckman Scintillation System. Water sam-

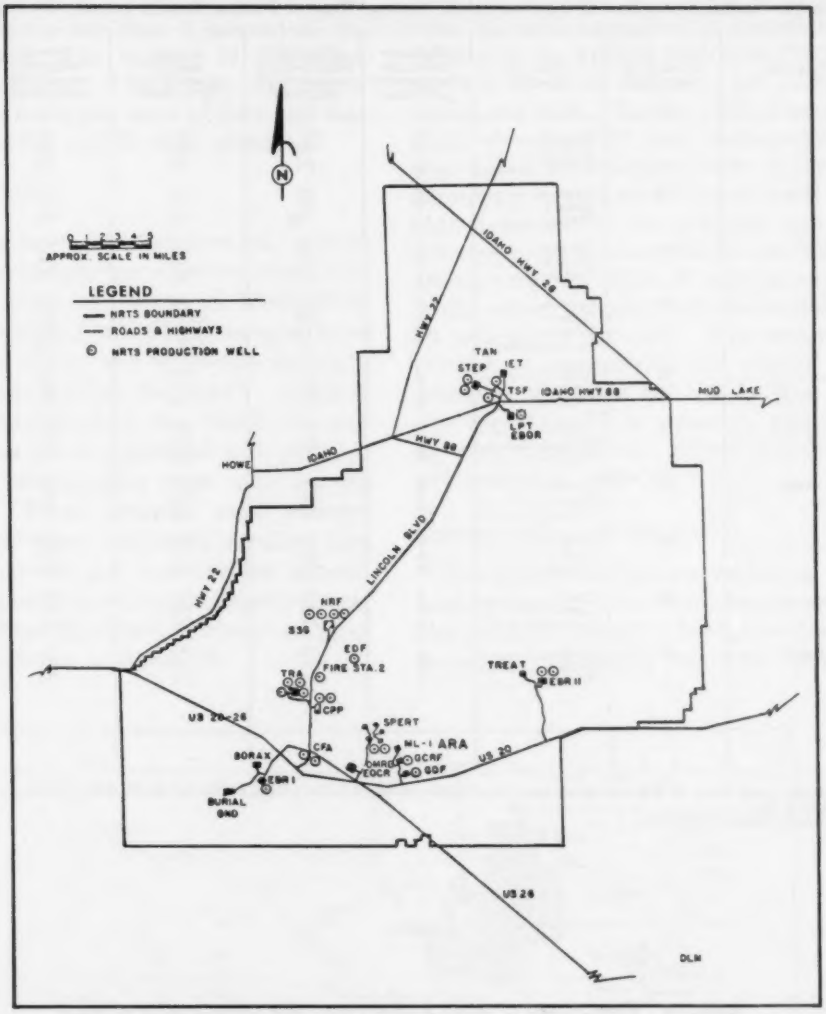

Figure 10. Onsite water sampling locations, NRTS

pling data are presented in tables 28 and 29. Samples collected from Mud Lake, Monteview, Reno Ranch, Idaho Falls, and Roberts (all upgradient in the aquifer from the NRTS) were used to determine background concentrations of radioactivity.

None of the offsite water samples collected during 1972 contained concentrations of radioactivity above the detection limits of the analyses. No onsite samples contained gross alpha concentrations above the detection limit of 3 pCi/liter. Of the wells used for drinking purposes, the highest single sample gross beta concentration, 33 pCi/liter, was found in well #1 at the Idaho Chemical Processing Plant. The 1972 average strontium-90 concentration

Table 28. Radioactivity in well water samples, National Reactor Testing Station, January-December 1972

Sampling locations	Number of samples	Type of analysis	Minimum detectable concentration (pCi/liter)	Maximum single samples concentration (pCi/liter)	Average sample concentration [a] (pCi/liter)	Average background concentration (pCi/liter)	Maximum average net concentration (pCi/liter)
EBR-I (1 well)	1	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	[b]	[b]	[b]	[b]
		Tritium	•2	[b]	[b]	[b]	[b]
CFA (2 wells)	26	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	[b]	[b]	[b]	[b]
		Tritium	•2	•99	•70	[b]	•70
TRA (3 wells)	104	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	[b]	[b]	[b]	[b]
		Tritium	•2	•2	[b]	[b]	[b]
ICPP (2 wells)	26	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	33	<12	[b]	<12
		Tritium	•2	•19	•6.0	[b]	•6.0
		Strontium-90	1	17	5.7	NA	5.7
NRF (3 wells)	42	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	[b]	[b]	[b]	[b]
		Tritium	•2	[b]	[b]	[b]	[b]
TAN (5 wells	129	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	[b]	[b]	[b]	[b]
		Tritium	•2	•2	[b]	[b]	[b]
SPERT-PBF (2 wells)	26	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	[b]	[b]	[b]	[b]
		Tritium	•2	•2	[b]	[b]	[b]
ARA (2 wells)	52	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	[b]	[b]	[b]	[b]
		Tritium	•2	•2	[b]	[b]	[b]
EBR-II (1 well)	26	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	[b]	[b]	[b]	[b]
		Tritium	•2	•2	[b]	[b]	[b]
Fire station #2 (1 well)	26	Gross α	3	[b]	[b]	[b]	[b]
		Gross β	5	[b]	[b]	[b]	[b]
		Tritium	•2	•2	[b]	[b]	[b]

[a] AEC standards—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium 3 000 nCi/liter, and strontium-90, 300 pCi/liter.
[b] Below detection limit.
• Concentration of tritium in nCi/liter.

Table 29. Radioactivity in offsite drinking water and surface water samples, National Reactor Testing Station, January-December 1972

Sampling location	Number of samples	Type of analysis	Maximum single sample concentration (pCi/liter)	Minimum detectable concentration (pCi/liter)	Average sample concentration (pCi/liter)	Average background concentration [a] (pCi/liter)	Maximum average net concentration (pCi/liter)
Carey, Aberdeen, Shoshone, Atomic City, Minidoka, and Arco:	12	Gross alpha	[b]	3	[b]	[b]	[b]
		Gross beta	[b]	5	[b]	[b]	[b]
		Tritium	[b]	•2	[b]	[b]	[b]
Snake River at Bliss, Idaho:	2	Gross alpha	[b]	3	[b]	[b]	[b]
		Gross beta	[b]	5	[b]	[b]	[b]
		Tritium	[b]	•2	[b]	[b]	[b]

[a] AEC standard—gross alpha, 30 pCi/liter; gross beta, 30 pCi/liter; tritium, 3 000 nCi/liter.
[b] Below detection limit.
• Concentration of tritium in nCi/liter.

at the ICPP was 5.7 pCi/liter. This strontium-90 concentration is less than 2 percent of the AECM standard. The highest 1972 average tritium concentration, 7 nCi/liter, was found at the Central Facilities Area (CFA) and was 2.3 percent of the AECM 0524 standard.

Food monitoring

Milk was the main foodstuff sampled. A composite grade A sample was collected from farm areas to the north and south of Idaho Falls each week. Monthly grade B milk samples were collected from dairies and individual farms in rural areas surrounding the NRTS. Analysis by gamma spectrometry for iodine-131 and cesium-137 was performed on all milk samples. Semiannually the samples were analyzed for strontium-90. Wheat samples were collected from individual farms and grain elevators during the fall harvest and analyzed for gamma-emitting radionuclides by gamma spectrometry and for strontium-90. Milk and wheat sampling locations are shown in figure 10.

All milk sampling results summarized in table 30 were compared to standards recommended by the Federal Radiation Council, since the AECM 0524 does not list concentration guides for milk. During 1972, the concentrations of iodine-131 and cesium-137 in milk were below the detection limits of the analysis. Strontium-90 concentrations in milk were less than 3 percent of the standard and were attributed to worldwide fallout, not NRTS operations. Only strontium-90 activity was detected in the wheat samples with the hull containing 90 percent of the total. This means only 10 percent of the activity will remain after the wheat is processed for use in food products. The strontium-90 in wheat is also attributed to worldwide fallout. Wheat sampling results are located in table 31.

Gamma radiation exposure

Environmental gamma radiation exposures were measured with thermoluminescent dosimeters (TLD) placed at background and NRTS boundary community locations. Exposures at

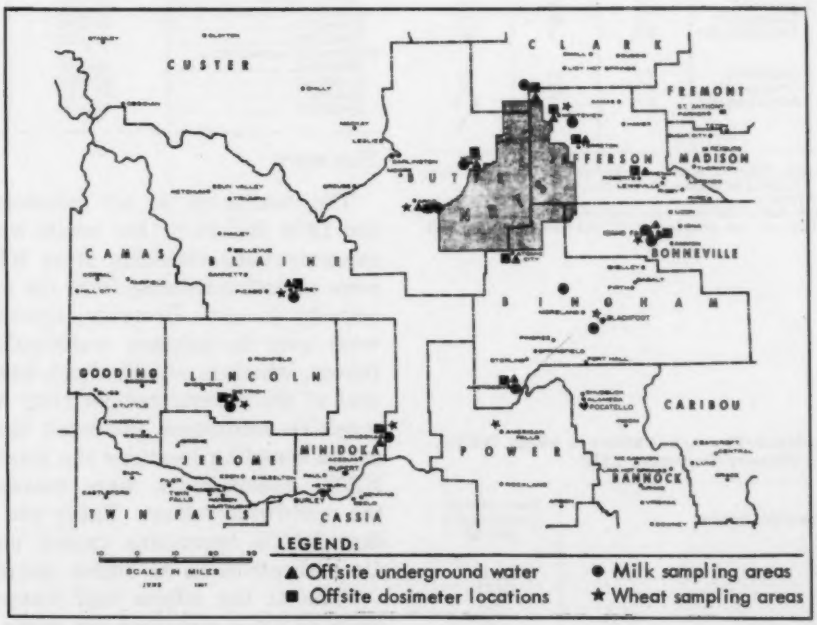

Figure 11. Environmental monitoring program, National Reactor Testing Station

Table 30. Radionuclide concentration in milk, National Reactor Testing Station, January-December 1972

Location and sampling frequency	Analysis	Concentration (pCi/liter)		
		Maximum single sample concentration	Minimum detectable concentration	Average sample concentration[a]
Idaho Falls: (weekly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	6.5	2	4.7
Minidoka: (monthly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	6.0	2	4.5
Dietrich: (monthly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	11	2	<6.5
Carey: (monthly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	5.4	2	<3.7
Mud Lake: (monthly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	6.3	2	6.1
Reno Ranch: (monthly)	Iodine-131	[b]	20	[b]
	Cesiun-137	[b]	30	[b]
	Strontium-90[c]	4.6	2	3.8
Tabor: (monthly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	4.3	2	4.3
Howe: (monthly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	<3.3	[d]	<2.6
Arco: (monthly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	4.6	2	<3.3
Firth and New Sweden, near Idaho Falls: (monthly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	2.7	2	2.7
Lake and Riverside (Tabor-Blackfoot-Aberdeen Area): (monthly)	Iodine-131	[b]	20	[b]
	Cesium-137	[b]	30	[b]
	Strontium-90[c]	4.0	2	3.4

[a] Federal Radiation Council standard: Iodine-131, 100 pCi/liter; cesium-137, 3 600 pCi/liter; strontium-90, 200 pCi/liter.
[b] Below detection limit.
[c] Only two samples during the year were analyzed for strontium-90.
[d] The detection limit for one sample was 3.3 pCi/liter and 2 pCi/liter for the other.

Table 31. Strontium-90 concentrations in wheat, NRTS, January-December 1972

Sampling location	Strontium-90 concentration (pCi/g)
Minidoka	0.021
Dietrich	.022
Carey	.016
Arco	.011
Monteview	.025
Idaho Falls	.022
Blackfoot	.010
American Falls	.013

the distant locations of Idaho Falls, Blackfoot, Dietrich, Carey, Aberdeen, and Minidoka were considered background levels. Measurements of boundary community exposures were made at Atomic City, Howe, Arco, Butte City, Mud Lake, and Roberts. The exposures reported in table 32 are for the period April 25 to November 20, 1972. The average exposure at each location and its associated error at the 95 percent confidence level (2σ) are listed. Boundary community exposures ranged from 81 $\pm$ 11 to 111 $\pm$ 36 mR. Background exposures ranged from 80 $\pm$ 6 to 101 $\pm$ 11 mR. There was no evidence that any of the exposures at the NRTS boundary communities were different from background or were the result of NRTS activities.

Table 32. Offsite gamma exposure, NRTS, April 25-November 20, 1972

Location	Exposure (mR $\pm 2\sigma$)	Equivalent yearly exposure (mR $\pm 2\sigma$)
Boundary community exposures:		
Howe	81 $\pm$ 11	141 $\pm$ 19
Monteview	83 $\pm$ 12	145 $\pm$ 21
Reno Ranch	82 $\pm$ 10	143 $\pm$ 17
Atomic City	111 $\pm$ 36	194 $\pm$ 63
Arco	84 $\pm$ 13	147 $\pm$ 23
Butte City	85 $\pm$ 16	148 $\pm$ 28
Mud Lake	87 $\pm$ 12	152 $\pm$ 21
Background exposures:		
Minidoka	80 $\pm$ 6	140 $\pm$ 10
Aberdeen	100 $\pm$ 12	175 $\pm$ 21
Roberts	101 $\pm$ 11	176 $\pm$ 19
Blackfoot	86 $\pm$ 6	150 $\pm$ 10

Summary

The results of the air monitoring program for 1972 indicated that onsite and offsite air concentrations resulting from NRTS releases were indistinguishable from the natural radioactivity in air. However, special techniques were used to measure worldwide radioactive fallout, which is usually much less than 1 percent of the natural radioactivity in air. These sensitive techniques indicated that at a few onsite sampling locations the small releases of NRTS radioactivity were measurable above the worldwide fallout. There was no evidence that NRTS operations caused any increased air concentrations at offsite communities.

None of the offsite well water or surface water samples contained any gross alpha, gross beta, or tritium activity above the detection limits of the analyses. The only fission or acti-

vation product detected in milk samples was strontium-90. However, the strontium-90 concentrations are similar to those reported for the region in the U.S. Environmental Protection Agency's *Radiation Data and Reports*, and the source is assumed to be fallout from nuclear device testing and not NRTS operations. Wheat samples collected at harvest also contained small amounts of strontium-90 from worldwide fallout.

Gamma radiation exposures were measured simultaneously at distant background locations and at communities near the NRTS boundary. There was no evidence that the exposures at the NRTS boundary communities were different from background.

REFERENCE

(8) HALLDEN and HARLEY. An improved alpha counting technique. Anal Chem 32:1861 (1960).

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Period	Issue
January-December 1971	March 1974

Reported Nuclear Detonations, October 1974

(Includes seismic signals presumably from foreign nuclear detonations)

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There were no reported nuclear detonations for the United States for October 1974.

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November 1974

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